DECEMBER 1984 VOL. 2, NO. 6 $3.95

FOR IBM PERSONAL COMPUTER USERS

PC TECH JOURNAL

[redacted]

IBM'S IMPRESSIVE PC/AT

Technical Evaluation
PC-DOS 3.0: Its New Features
IBM PC Network
iAPX 80286: Overview

12
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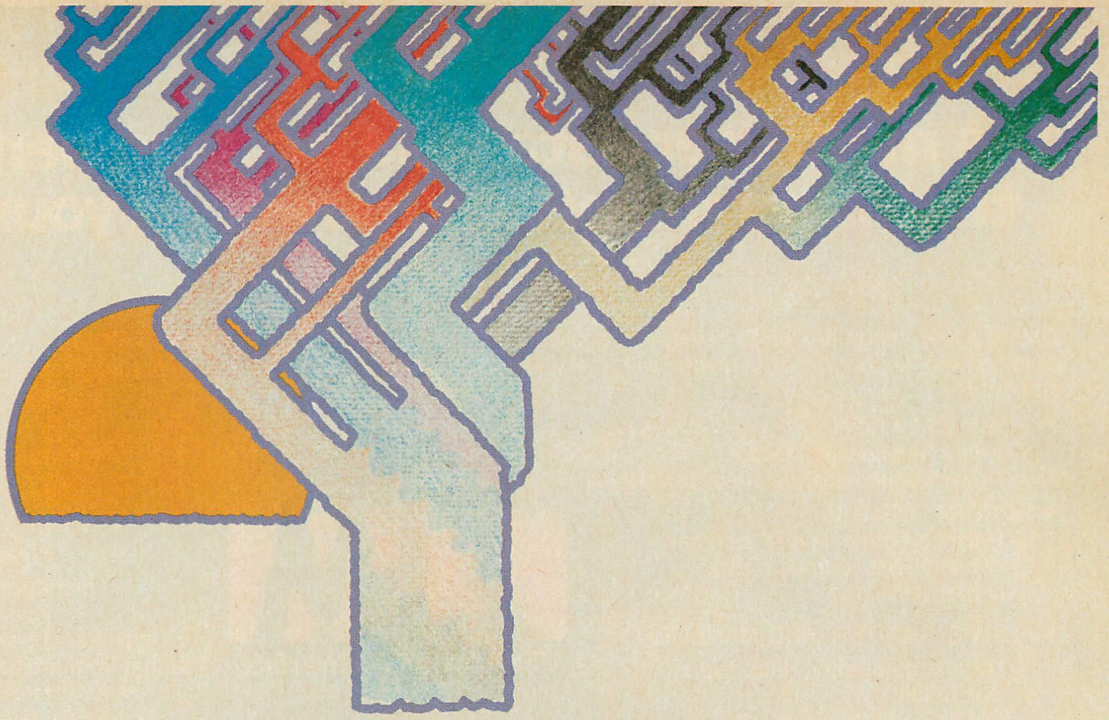

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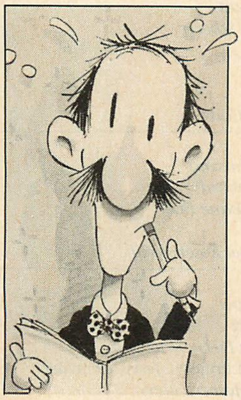

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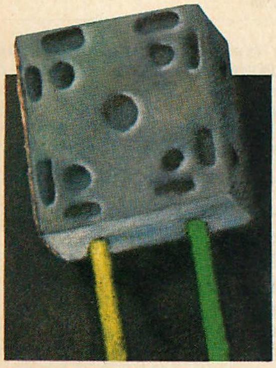

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ATtention to Detail

IBM listened. Then it built the PC/AT

I have a habit of being disappointed by IBM's new machine announcements. Excited as I was about the PC, I moaned and groaned about the keyboard. The PC/XT failed to deliver an effective (and at first, bug-free) back-up scheme. The PC*jr*. . . well, keyboard woes again. Then there's the Portable. . . oh, and the Cluster.

I was certainly not untouched by the eight-month speculation campaign about the AT waged by the press. My expectations were suitably high, and I had formed my own idea about how the AT would look. It was no surprise to discover I was wrong, and no surprise to find myself disappointed.

That was two months ago. Today, after an almost unabated stream of product announcements by IBM, I still have a couple of bones to pick, but I am impressed overall. In fact, we're all quite impressed. That's why this issue of *PC Tech Journal* is almost entirely devoted to IBM's new PC entry.

THE DISAPPOINTMENTS

Let's get the bad news out of the way first. There is a severe, nagging annoyance; a flaw; and a problem that has recently been solved.

The annoyance is the lack of good back-up capability. It is particularly irritating that this is the second time—first with the XT, and now the AT. To be sure, backing up 20MB to 18 high-density diskettes is a little better than 10MB to 30 DSDD diskettes, but what we need is what Mountain Computer so quickly announced for the AT (and which we review on page 150): a tape back-up unit that does the job in six minutes without user intervention. Compaq has the right idea with its DeskPro+ series. Where are you, IBM?

The flaw is the keyboard. I know what you're thinking: "What!? Again? Hey, Will, I thought it was fixed!?" Yeah, me too. Well, actually, it was fixed. IBM really did listen, and all the gripes everyone made about the original keyboard have been redressed. There are shift key indicators. The major keys are big and where they belong. There are some other less noticeable improvements. There is even a new key, "SysReq," that makes me think the AT is a 360 in disguise. But, after fixing all the problems, IBM went and moved the Esc key from the position where I have expected it for the last 14 years to a place in which I have never seen it before. I have already begun work on a device driver that remaps it back; thank goodness the keys pop off.

The solved problem was also the source of my greatest initial disappointment: no new graphics standard. But a month later, IBM announced two graphics subsystems, both of which I consider good, albeit somewhat expensive. Now the AT can be configured from the low end with an IBM monochrome system to the high end with the Professional Graphics subsystem, turning an AT into a graphics workstation of a caliber previously available only in dedicated graphics systems. I may quibble over prices and specifications, but IBM has delivered a comprehensive answer, including software.

THAT'S IT

Other than that, I think the PC/AT is a superb machine. What I am most impressed by, however, is IBM's attention to detail.

It shows up everywhere. For example, the nameplate on the front of the system unit swivels so that the IBM logo can be oriented properly when the machine is mounted in IBM's floor stand. Trivial perhaps, but just think about all the work that goes into making such a simple concept manufacturable.

There are more important examples. The dual bus, enabling the AT to use both the new, 16-bit adapters as well as the older PC boards, was not a trivial task. We have plugged a variety of PC boards into the AT, and all have worked. IBM even announced the machine with the PC's two display adapters as the only way to connect a monitor! That dual bus was harder to build than a single, 16-bit bus, but it was necessary for compatibility. IBM bit the bullet.

The AT's BIOS is full of care and attention. Through it, IBM has given us tremendous compatibility

with prior members of the family and has made the AT a full-fledged, if somewhat more sophisticated, sibling. The hardware architecture of the machine also supports PC compatibility, as does the new version of IBM DOS. Taking the AT out for its first spin was actually kind of routine: most of the PC-DOS software we tried to run, did run. Those packages that did not run are known to disobey PC and DOS rules in the extreme.

FASTER THAN A SPEEDING XT

The AT brings a new attribute to the PC family: speed.

I'm used to minicomputers—and pretty spiffy ones at that. I have always thought the XT was a bit sluggish, especially when executing batch (.BAT) files. A lot can be done with batch files (on my mini we performed minor miracles with them), but they are so painfully slow that small, simple ones are more typical. Not so on the AT. With a processor that's at least twice as fast and a disk (and this is the significant point) that's about three times as quick as the XT's, batch files hum right along.

Batch files are a subtle benchmark, but they illustrate one of the AT's most important strengths: improved disk performance. Fast disk I/O is vital if the machine is to be used as a file server in a network or the engine in a multiterminal system. Once the 80286 is fully exploited by a multiuser system, good disk performance is necessary for efficient handling of swapping and virtual memory management.

We have prepared a benchmark report (page 108), using the same measurements we have used before. Our mixed results indicate we have more to learn about the nature of the new machine. Programs written with the 8086 in mind, as opposed to those written in 8080-style or otherwise removed from the native machine, run very fast. The program editor and word processor I use, both of which live in the DOS/8086 environment, run so fast that the hello screens vanish before they can be read. The word processor is overlaid, but that penalty has also vanished.

No, the AT is not the quickest 80286 box around. IBM decided upon a conservative 6MHz clock (although it did mount the crystal in a socket), leaving the speed of the machine in the same ballpark with many of the other 16-bit, 8086 machines already announced by other vendors. Several smaller companies build boxes around the 86 that make an AT look sick. Nonetheless, the AT represents a strong step forward in the performance area and will address the needs of many users for whom the XT may have been only marginally useful.

DOS

Attention to detail is also the hallmark of the new version of IBM DOS 3.0. Julie Anderson's report (page 74) gives the details, but a few examples make the point.

An annoyance of DOS when used on an XT, and when a complex directory structure is used, has been the inability to run a program that lived in another directory. A partial solution has been the PATH command, which allows COMMAND.COM to look in a number of other directories for the program. What's been irritating is that a command like A:FORMAT works, while C:/DOS/FORMAT does not. With DOS 3.0 they both work, another subtle but important improvement.

Another problem has been that programs living in subdirectories could not find their ancillary files if they were invoked from another directory. This has meant that programs needed to be executed from their own working directory and that data files, such as spreadsheets, often needed to be in the same directory or on a diskette. I am aware of only three programs for the PC that solve this problem: WordPerfect, Nutshell, and PC/Focus. Now DOS 3.0 includes a mechanism so that programs can determine from whence they are executing and thus find needed files. That means the data files can be in a more appropriate directory. Subtle again, but important for improved usability.

One more. DOS 3.0 can create a file with a unique name. The capability, which is easy to design and build, is of vital importance to network and multiuser applications. It is also one of a set of DOS functions that, for the first time, clearly show the bridge to UNIX.

THE NETWORK

Things are really starting to come together now, folks.

Susan Glinert-Cole provides our first look at the IBM PC Network (page 90), and we will have more to come in forthcoming issues—as soon as we can get our hands on the hardware. For now, just remember that we finally have an IBM endorsement of LAN, that we thus have a standard, and that the market is about to open up for the first time. Try to keep your feet firmly on the ground.

LOOK OUT!

What we have here is a very competent, very impressive, new computer. We know it's a hot desktop machine. We know it's a fast XT. We know it will be used as a network server. We know it's an IBM.

Tom Hoffmann herein (page 40) reveals some of what we have found inside the machine—features that point to good planning and more to come. Things such as support for a 100MB fixed disk. Bigger graphics memory. And more.

A lot remains to be learned about the AT and what we will do with it. But what *that* means is simple. Clearly, the AT is IBM's small computer of the future, and it can and will take us beyond our current horizons to new limits of productivity and creativity.

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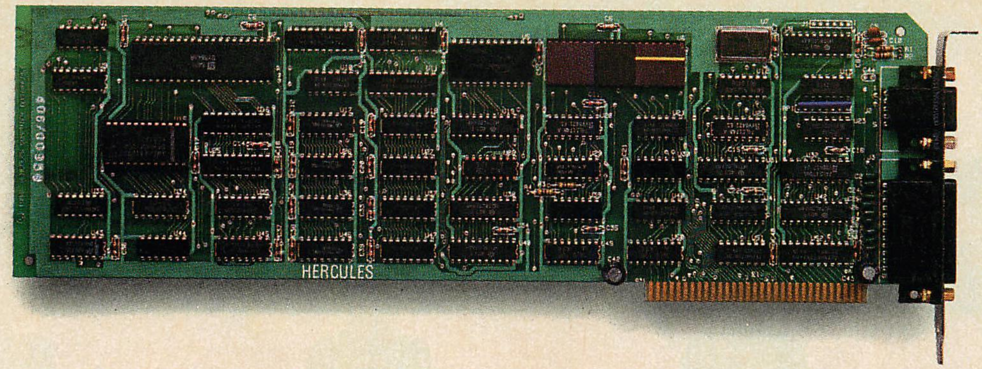

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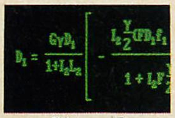

There are programs that enable your PC to emulate a graphics terminal and run mainframe graphics software.

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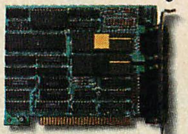

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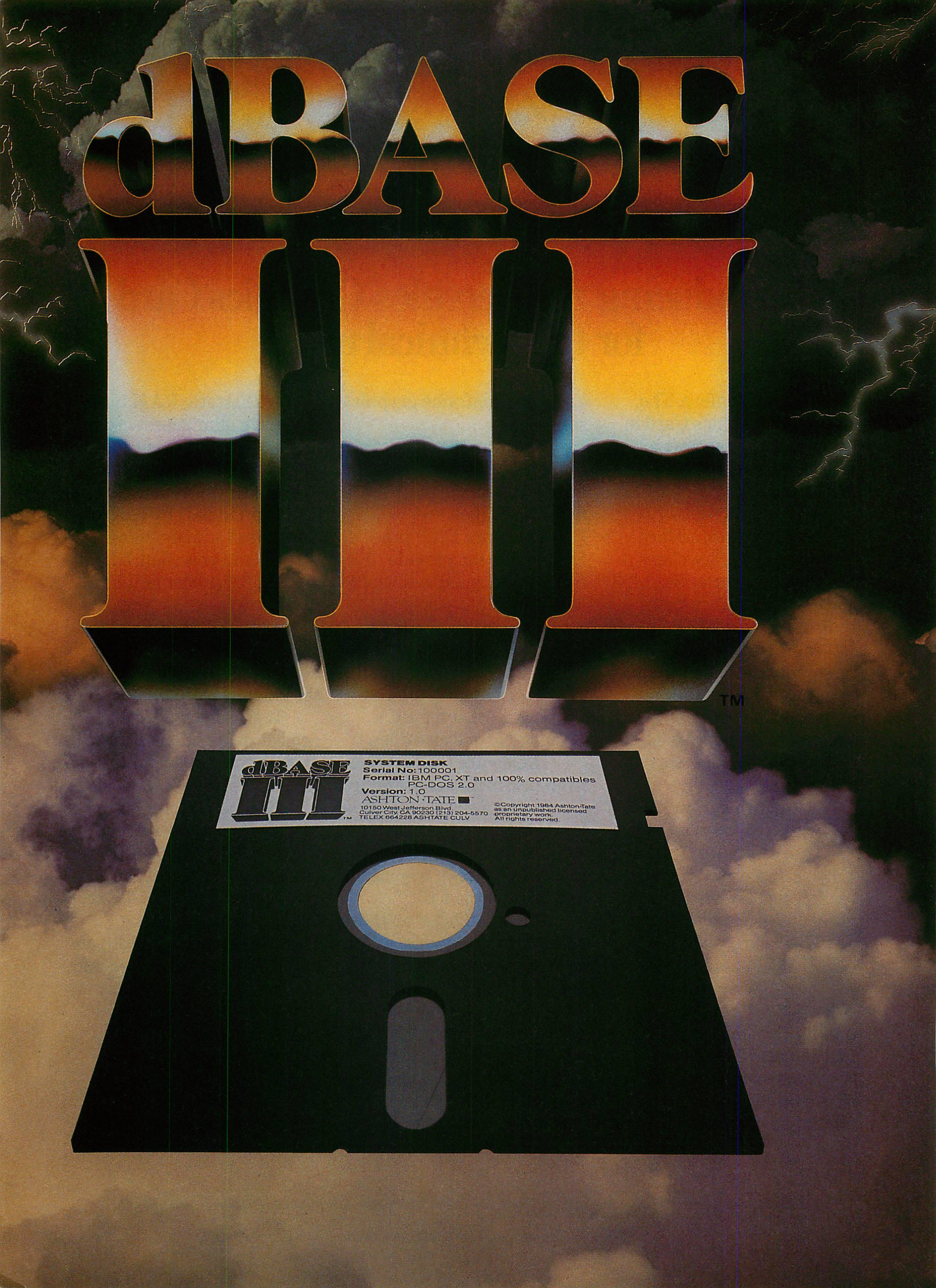
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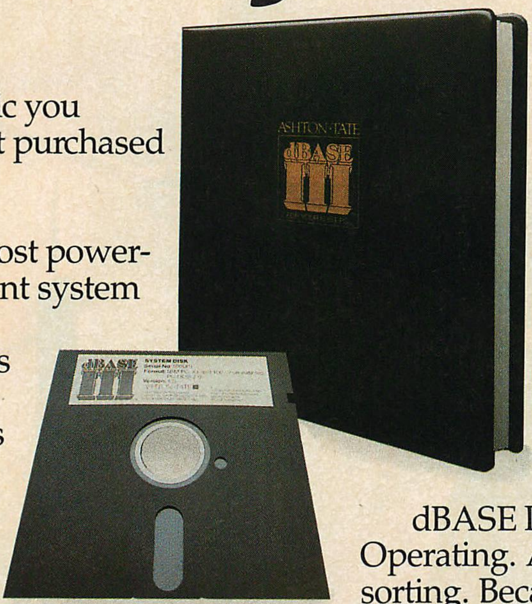

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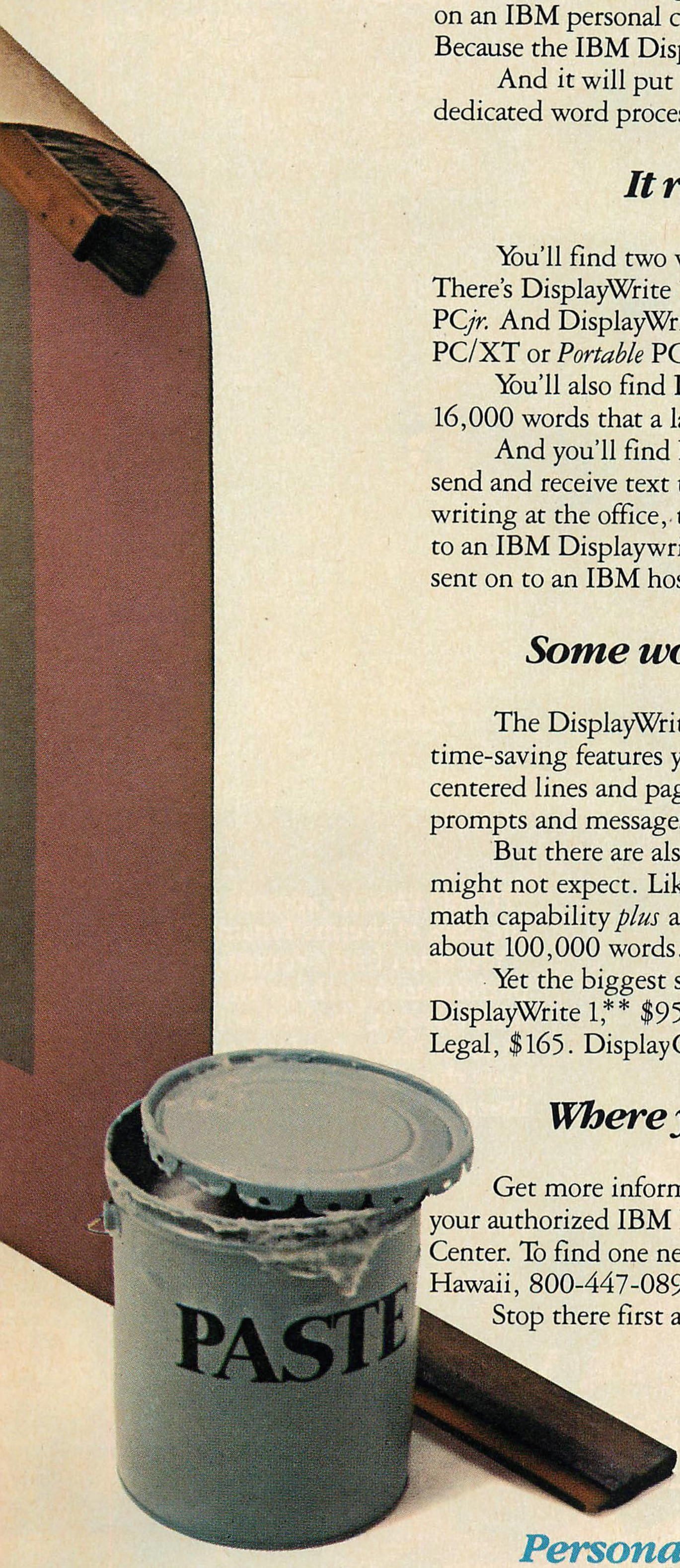

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And you'll find DisplayComm, which lets your IBM PC send and receive text to and from other IBM PCs. If you're writing at the office, this program could also let you send text to an IBM Displaywriter down the hall. (From there, it could be sent on to an IBM host computer for distribution.)

Some words on high function.

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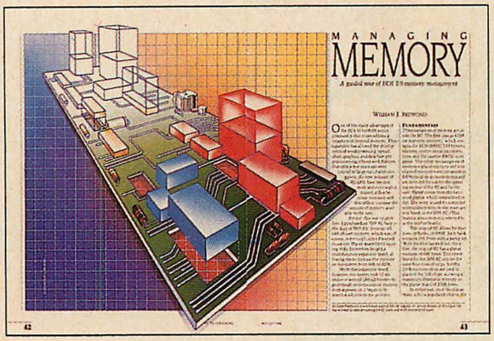
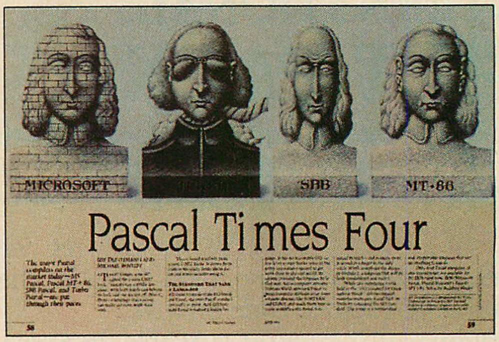




MEMORY RECOGNITION

First of all, I salute William Redmond and all others whose brains race so fast that they cannot wait for the IBM PC to check memory during power-up. I find that this time is useful for making a cup of coffee, feeding the cat, or getting a bowl of ice cream to calm my shattered nerves (especially if it is a power-on reboot after a system crash).

My PC has 704KB memory installed, which is more than the 544KB that can be set on the motherboard sense switches. Getting DOS 1.1 to recognize the extra memory was no problem, as Redmond discusses in "Managing Memory" (August 1984, page 42). The way to modify DOS 2.1 to make it recognize the extra memory eluded me, so his article was very informative.

However, there is a simple way (via an assembly language program) to make all versions of DOS recognize memory above the switch settings. Determine the actual memory size in kilobytes and store it in the word at 40:13. Then reboot DOS by executing a software interrupt (INT 19H). INT 19H, unlike pressing Ctrl-Alt-Del, does not erase the screen or reset any data from ROM BIOS. I have successfully tested this on the PC, the PC/XT, and the Compaq. If you are using such a program in an AUTOEXEC.BAT file, be sure to set a flag in low memory or the screen buffer to prevent endless reboots.

The penalty for this simplicity is having to wait for DOS to load twice. So enjoy another spoonful of ice cream.

Patrick Spangler
Pleasanton, CA

PASCAL CONFUSION

You recently featured a letter from Dennis C. During expressing his confusion with Microsoft Pascal and its use of the 8087 ("Pascal Opinions," October 1984, page 12). In particular was the statement that a patch was required if a computer system meets certain criteria. The IBM PC does meet the criteria, and so it would seem that the patch would be required to use the 8087. Jeff Duntemann, in reply, stated that the patch was not used in the tests that he had done in writing his review of Pascal compilers ("Pascal Times Four," July 1984, page 58), and, further, that Microsoft was in error for stating that a patch was needed. Mr. Duntemann is almost correct in the first part of his reply, but dead wrong in the second.

There are three criteria for a patch being needed: (1) the 8087 uses an interrupt vector other than 2; (2) there is an 8259A PIC in the system; (3) the 8087 shares interrupts with another device. Mr. During, in his letter, goes through these criteria and comes to the wrong reason for a patch being needed. In the process, he shows an extreme amount of confusion.

On an 8088, there are two interrupt lines, NMI and INTR. NMI is the "nonmaskable" interrupt, while INTR can be masked. This means that if a signal appears on the NMI line, the 8088 cannot ignore it. If, however, a signal appears on the INTR line, the 8088 can ignore it if it chooses to do so. NMI always generates a type 2 interrupt (*iAPX 86/88 User's Manual,* page 2-24). INTR, on the other hand, generates an interrupt of the type specified by the 8259A (if present), ranging from 0 to 255.

IBM, in its infinite wisdom, chose to ignore an Intel recommendation that the 8087 never be tied to the NMI line (*iAPX 86/88 User's Manual,* page S-27). NMI should be used only for catastrophic events, such as power loss, memory errors, I/O bus errors, etc. IBM does use NMI in this manner to report memory parity errors. However, it also uses NMI for the 8087 exception reports, which means we can finally go back and see why the patch is needed.

The IBM PC uses interrupt 2 (NMI) for 8087 exception reporting, so patching for criterion 1 is not needed. The PC does have an 8259A. However, it is on INTR, and the 8087 uses NMI. Hence, no patching for criterion 2 is needed. Finally, does the 8087 share the interrupt (type 2) with another device? Indeed it does. Parity errors are reported using NMI. A parity error can be a real bad thing. Since the PC memory space is not protected, undetected parity errors could result in physical damage to a PC. By not installing the patch, parity errors would be treated as 8087 exceptions. The 8088 would service the 8087 exception and then, finding no error, return or hang in the service routine. In either case, no report of the true problem would be made.

Mr. Duntemann's statement that no problem was encountered without installing a patch is quite correct. Parity errors are extremely rare. However, why take the chance?

William J. Rust
Billerica, MA

What Mr. Rust says is entirely correct. To avoid conflicts between parity errors and 8087 exceptions, the patch should be installed. In three years of using my PC, I have never seen a parity error, so in my opinion the risk inherent in not patching the compiler is fairly small. But if you are comfortable with Debug, there's no reason not to put it in.
—Jeff Duntemann

I was very excited to see the review of four Pascal compilers in the July issue. I was even more excited when I read that the latest version of the Microsoft Pascal compiler included "a proprietary linker . . . symbolic debugger, assembler, librarian, and screen editor." Since I already owned a copy of this compiler, I could hardly wait to call Microsoft to order my update.

READ  ONLY

A review of the IBM Personal Computer Family. Vol. 1, No. 2

HARDWARE NEWS

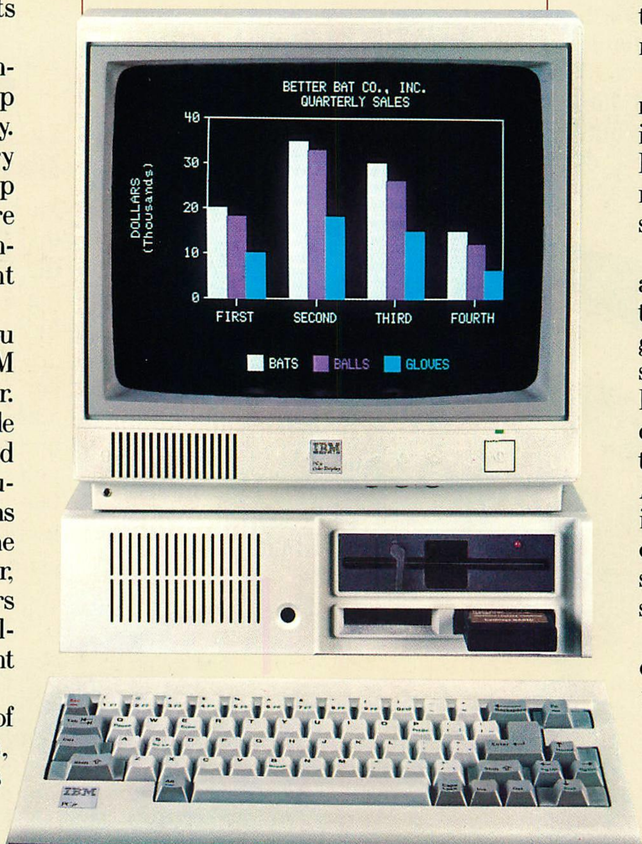
Progress. Even for a youngster with unusual potential, the IBM PC*jr* has made a lot of progress in its first year.

Consider memory for example. The IBM PC*jr* comes with up to 128KB of internal user memory. You can also add external memory expansion units of 128KB each, up to a total of 512KB. That's far more potential memory than other computers of its price range and weight class (10 pounds).*

Increased memory allows you to take full advantage of the IBM PC*jr*'s powerful 16-bit processor. With up to 512KB of available memory and PC*jr*'s double-sided diskette drive, you can run thousands of best-selling programs that have been developed for the IBM PC. If you're a programmer, the PC*jr* joins the other members of the IBM PC Family as a full-fledged application development tool.

There is also a variety of plug-in cartridge programs, which work faster than diskettes and don't take up any user memory. Three popular examples are Lotus 1-2-3™, PC*jr* ColorPaint, and Managing Your Money™ by financial expert Andrew Tobias. And every PC*jr* comes with cassette BASIC built into the system board.

PC*jr* makes it easy and affordable to start small and grow at your own pace. The $599 PC*jr* Entry Model, for example, comes with 64KB of memory, runs cartridge programs, and can easily be expanded into a diskette model. The PC*jr* Enhanced Model at $999** offers 128KB of memory—enough to run many programs from the IBM PC software library—and a 360KB diskette drive.



Cartridge-based programs for PCjr include Lotus 1-2-3™.

No matter which model you choose, the IBM PC*jr*'s 13 ports for plug-in options make it easy to add to your system, from more memory, to a modem, joysticks (PC*jr* can accommodate two), color monitor, or other peripherals.

Keys and colors. The IBM PC*jr* now comes with a new typewriter-style cordless keyboard that frees you to work up close or across the room from the system unit.

While PC*jr* can be connected to just about any display, including your TV set, the IBM PC*jr* Color Display offers some real advantages at a very reasonable price.

It has a built-in speaker and an earphone jack for educational and entertainment programs that feature music and sound effects. The non-glare RGB screen gives you better character definition and clarity than a color composite monitor. And since the PC*jr* Color Display is designed to be placed on top of the system unit, it's a space-saving addition to your PC*jr* system.

Whatever monitor you decide to add to your PC*jr* system, there's no extra expense for an additional interface card. Ports for both monitors and serial printers are built in.

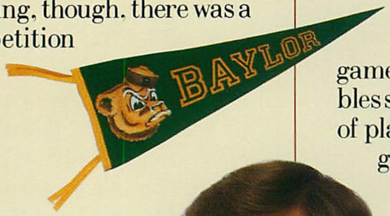
*Weight does not include power pack and monitor.
**Prices shown apply at IBM Product Centers.
Lotus 1-2-3 is a trademark of Lotus Development Corporation.
Managing Your Money is a trademark of MECA.

UP AND RUNNING

First String. It didn't take the IBM PC*jr* long to make the team. In its first year of eligibility, PC*jr* was picked by coach Grant Teaff to play a key position for the Baylor University football team.

Coach Teaff has a practiced eye for players with potential. He's coached the Baylor Bears to two Southwest Conference championships, been named Southwest Conference Coach of the Year five times, and was National Coach of the Year in 1975.

The Bears' coaching staff has used computers to help analyze scouting reports and playing patterns of opposing teams for nearly ten years. In the beginning, though, there was a lot of competition for a limited amount of computer time.



Coach Teaff and his assistant coaches had to write up all their game and player information and then have it keypunched. After that came a wait for processing time on Baylor University's mainframe computers, time that had to be shared with other departments and the university administration. Analysis of a game often wasn't available until a week after it had been played.

PC*jr* helped change all that.

Winning Tendencies. Coach Teaff calls the IBM PC*jr* "the ideal football coaching tool." With up to 512KB of available memory, it's powerful enough to make his staff independent of the University's central computers. And PC*jr* and the PC*jr* Color Display are inexpensive and compact enough to be used in offensive and defensive staff meeting rooms.

Using software developed by Coach Teaff, PC*jr* enables the Bears' coaches to enter information as they view game film of an opposing team and to see results immediately. When play-by-play statistics of several games are compiled and analyzed on PC*jr*, the coaches are able to identify tendencies of a team in given situations. They're then able to adjust their own game plan accordingly.

When Baylor plays new opponents, for instance, the two teams exchange films of past games. PC*jr* is used to analyze variables such as down, distance, and type of play. The Baylor coaches enter the game with much the same level of knowledge as if they'd played the new team for years.

The IBM PC*jr* helps out with other coaching duties as well. Team statistics, information about possible recruits, and numerous business and financial chores are all part of its workload.

Other coaches around the country had a chance to see the benefits of computerized coaching techniques this summer when members of the Baylor coaching staff demonstrated their programs at the nationwide football and basketball clinics sponsored by The Coaches, Inc.

Coach Teaff points out that a PC*jr* could make the difference between winning and losing to teams—small high schools, for example—with a limited budget and coaching staff. Using the PC*jr*, he says, "is like adding two or three men to the staff."

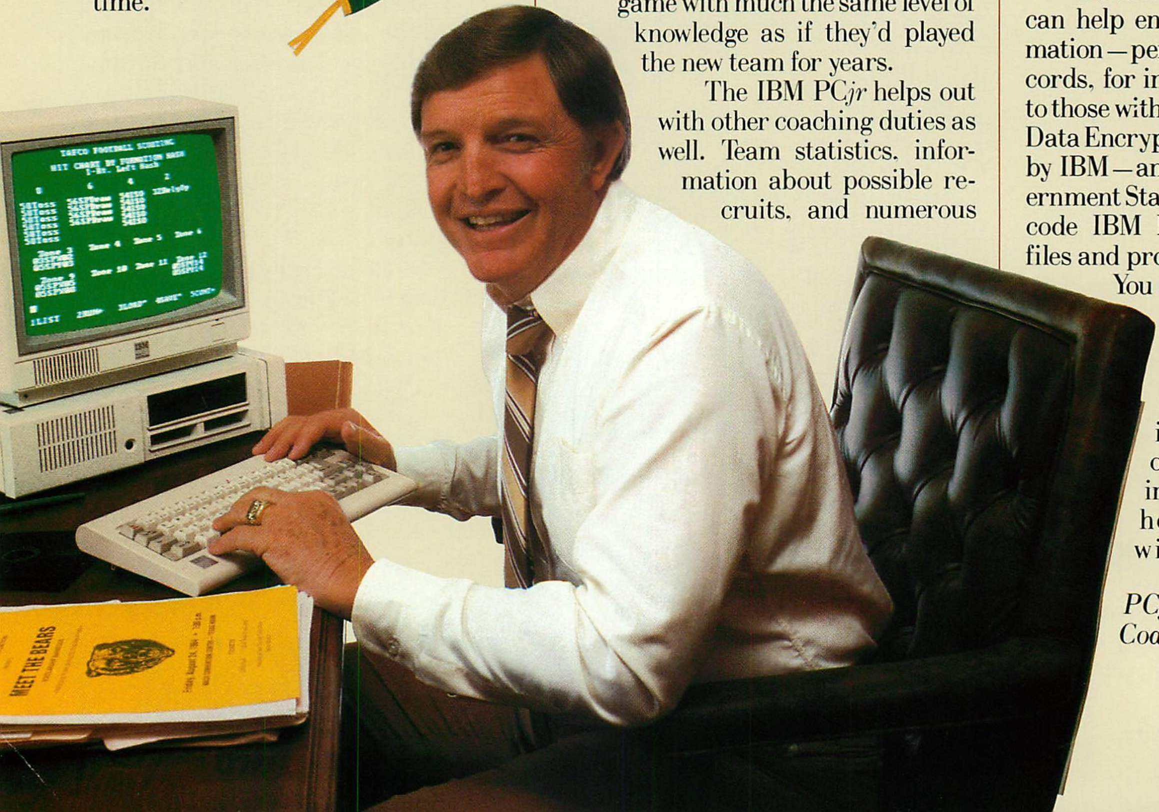
Not bad for a 10-pound, first-year player.

WHAT'S THE PROGRAM?

Maximum Security. Some information belongs under lock and key. But the rapid growth of personal computing and computer networks makes it increasingly difficult to keep it there.

Data Encoder software from IBM can help ensure that sensitive information—personnel and payroll records, for instance—is available only to those with a need to know. It uses the Data Encryption Algorithm developed by IBM—and adopted as a U.S. Government Standard—to encode and decode IBM Personal Computer data files and programs.

You don't have to be a master cryptographer to use Data Encoder. For members of the IBM Personal Computer Family with 192KB of memory, there's a full screen interface with menus and help screens. Systems with 128KB use easy



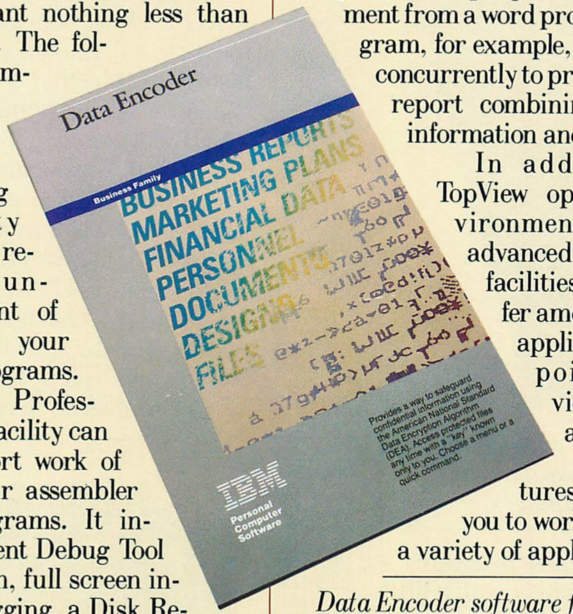
PCjr is a team player for Coach Grant Teaff.

DOS-like commands. You designate the key that triggers encoding and decoding procedures.

Files protected by Data Encoder can still be sent through IBM Personal Communications Manager or any other communications program with a text transparency feature. Without Data Encoder software and the proper security key, however, the information remains unintelligible.

So much for prying eyes.

In the clear. While some people are determined to keep things confidential, others want nothing less than perfect clarity. The following new members of IBM's growing family of programming productivity tools can help remove that unwanted element of mystery from your application programs.



Data Encoder software from IBM.

The IBM Professional Debug Facility can help make short work of improving your assembler language programs. It includes a Resident Debug Tool for full function, full screen interactive debugging, a Disk Repair Program, and a Non-maskable Interrupt card for access to a system that's locked because of program error.

The IBM Personal Computer Application Display Management System (ADMS) simplifies creation of clear, informative screens for application programs. Since screen development is one of the most time-consuming programming tasks, ADMS can help dramatically increase your application development efficiency and productivity.

ADMS consists of two parts. The Application Display Designer is a screen building program that significantly reduces the program coding required for an application. The Application Display Manager is a runtime program that interprets the screen design code.

Screens defined with ADMS remain independent of the application program, so they can be modified or redefined without affecting the logic of the application.

The view from the top. It's worth noting that programs developed with the help of ADMS can run under TopView, IBM's new multitasking operating environment.

TopView's multitasking capabilities allow you to work quickly and efficiently with a wide range of application programs. You can switch rapidly from one program to another without reloading diskettes and can copy information from one application to another. Sales figures from a spreadsheet program and a document from a word processing program, for example, can be used concurrently to produce a sales report combining financial information and text.

In addition, the TopView operating environment supports advanced windowing facilities, data transfer among different applications, and pointing devices such as a mouse. All are features that enable you to work easily with a variety of applications.

There's also an IBM TopView Programmer's Toolkit available that contains the routines, utilities, and systems related information necessary to develop applications that run under TopView.

FUN AND GAMES

Medieval adventures. The ideal game is easier to define than to find: it should be entertaining *and* enlightening. There are new programs from IBM that manage wonderfully to be both.

King's Quest from IBM, for example, is chiefly for fun but does impart a few important lessons. The hero of this colorful three-dimensional adventure game, the valiant Sir Grahame, is sent by the King of Daventry to search the countryside for three magical items that will prevent the

King's Quest software from IBM.

kingdom's collapse. Along the way, he encounters dangerous creatures, makes new friends, and avoids—or tries to avoid—treacherous terrain.

King's Quest is unusually enjoyable because you interactively control Sir Grahame's wanderings, helping him duck, jump, or swim his way through the quest. Many tasks can be solved in different ways, and more creative solutions are awarded higher scores.

Hence also the educational value. Cleverness and imagination are rewarded. And a few valuable practical lessons are reinforced along the way. Looking, for instance, before one leaps into alligator-filled moats and deep, dark holes.

King's Quest runs on the IBM PC*jr* and makes good use of some special PC*jr* capabilities. Sir Grahame's movements, for example, are unusually smooth and realistic because multiple video buffers in main memory are used instead of a single chip to create the animation effects. PC*jr*'s three voice sound creates an impressive variety of sound effects, such as a fanfare of horns when the castle door opens. And PC*jr*'s ability to produce 16 colors lends a touch of realism to an imaginary kingdom.

Modern machines. But can a program with more serious didactic intent be as enticing as Sir Grahame's rough and tumble lessons? Yes, if it's Rocky's Boots™, winner of *Learning* magazine's Software of the Year award and of high praise from *The New York Times*.

In fact, Rocky's Boots from IBM is also a quest for creative solutions to a series of different games. Along the way, both children and adults can learn the basics of electronic circuitry and of the Boolean logic that drives computer operations.

Lest that sound too intimidating, remember that the learning is a by-product of games in which you build various simulated machines on your display screen. Early sections of Rocky's Boots guide you through basic instructions about building and activating simple electronic devices.

You're also introduced to the various "spare parts" and "tools"—such as clackers, boppers, alligators, and alligator detectors—that may come in handy. Later in the program there are more challenging games to play using the machines you've built.

All in all, Rocky's Boots is as thoroughly engrossing as King's Quest. And on one point, at least, it's easier. Sir Grahame has to make do without an alligator detector.

Christmas cheer. Rocky's Boots and King's Quest are part of a special Christmas collection of entertainment and educational software from IBM.

Some others in the Christmas collection come from the same series of IBM learning games as Rocky's Boots. They include Bumble Games™, Bumble Plot™, Gertrude's Puzzles™, Gertrude's Secrets™, and Juggles' Butterfly™. See your authorized IBM Personal Computer dealer, IBM Software dealer, or IBM Product Center for complete details.

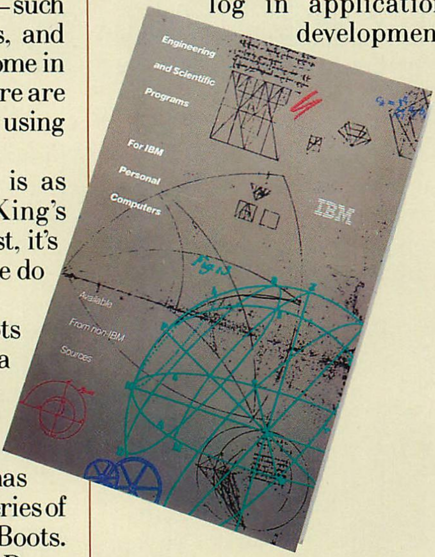
The Learning Company reserves all rights in the Juggles, Bumble, Gertrude, and Rocky characters and their names as a trademark and under copyright law.
Bumble Games, Bumble Plot, Gertrude's Puzzles, Gertrude's Secrets, Juggles' Butterfly, Rocky's Boots, and The Learning Company are trademarks of The Learning Company.

HARDCOPY

Full Disclosure. If business applications or entertainment programs aren't what you're after, there's a new software listing available from IBM, one with a long title but a specific purpose: the directory of *Engineering and Scientific Programs for IBM Personal Computers Available from Non-IBM Sources.**

It lists programs in a wide variety of engineering/scientific categories, from Computer Graphics to Lab Automation and Statistical Techniques. The *Engineering and Scientific* directory includes program descriptions, minimum configuration requirements, initial availability dates, and vendor information.

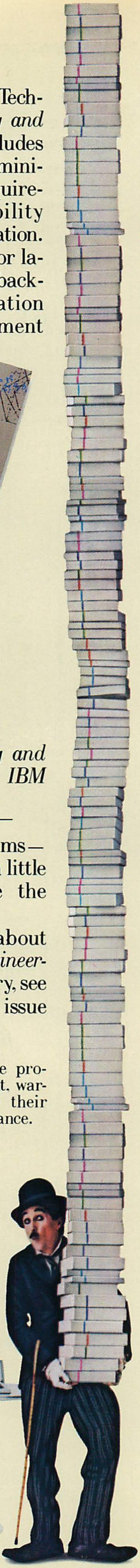
If your department or laboratory is suffering a backlog in application development work, one of these programs—in original form or with a little modification—may be the answer.



Directory of engineering and scientific programs for IBM Personal Computers.

For information about where to get the IBM *Engineering and Scientific* directory, see the box at the end of this issue of *Read Only.*

*IBM has not evaluated these programs and makes no comment, warranty, or guarantee as to their functions, quality, or performance.



TIPS AND TECHNIQUES

Living Dangerously. Diskettes lead dangerous lives. When they're not being folded, stapled, or otherwise rendered unfit for service, you might think they could at least spend a quiet evening in front of the TV set.

But no. Danger lurks there, too. All color TV sets and many color monitors have a degaussing coil around the face of the tube that demagnetizes the shadow mask inside the tube when the set is turned on.

If you keep your diskettes anywhere near (within a foot or so) the front of your color monitor or TV set, they may be exposed to a large shot of AC magnetic field every time you turn on the power. This could have a fatal and irreversible effect upon the data stored on the diskettes.

Don't degauss your diskettes.

IBM CREDIT CARD

The new IBM Credit Card gives you a convenient way to get started in personal computing or to add hardware and software to your IBM Personal Computer system. It's available with any purchase of $300 or more. You can apply for the card and make a purchase with it on the same day. See your IBM Product Center or participating authorized IBM Personal Computer dealer for details.

For more information about IBM Personal Computer products discussed in this issue of *Read Only*, see your authorized IBM Personal Computer dealer or IBM Product Center. To learn where, call 800-447-4700. In Alaska and Hawaii, 800-447-0890.

Alas, you misinformed me. According to the Microsoft representative, the new version does *not* include any of these utilities except the linker. The enhancements to the compiling system Microsoft is now releasing include full support for DOS 2.x directory paths by the compiler, linker and generated code, a few bug fixes, and support for BCD arithmetic. I'm disappointed. Where did you get your information?

This seems to fit into an interesting pattern of problems that are developing between me and your magazine. My initial excitement over the quality of articles in your first few issues has fizzled somewhat. Those first articles were by no means perfect, but they promised better things to come as you matured and improved. I'd hoped I'd found the programming companion for the PC that I needed. I am sorry to say that in several ways you have not kept up to my expectations. Many of your articles have had a decidedly novice orientation, many just simply are not on topics in which most programmers are interested, in my opinion. Your issue completely devoted to dBASE II was probably very interesting for those who use that product, but it left me completely out in the cold for a month.

I haven't given up hope, mind you. There's still a lot of good stuff in there. Despite the inaccuracy about what was included in the Microsoft Pascal system, the comparison of the four compilers was right on. How about some articles on Modula-2, Prolog, and some of the other new languages? I know you will be telling us all about DOS 3.0 and IBM's TopView. Just be sure to tell more than the other PC magazines.

William Weinberger
Irvine, CA

An error in the editing process led to the inadvertent omission of the very important word, not, in the sentence to which you refer. It should have read "A symbolic debugger, assembler, librarian, and screen editor are not included." I am sorry for the disappointment it caused you. Your interest in Modula-2 should be satisfied by reading the two-part series concluding in this issue with "Modular Implementations." "Modular Constructions" ran in the November issue. Also, you will find a complete review of DOS 3.0 in this issue.

—WF

GRATIFYING ISSUE

Thanks for your excellent magazine. I dropped your June 1984 issue as I had no interest in dBASE II at that time. But a problem has come up (as they often tend to do), and with *PC* magazine doing only the medium-size databases in its recent survey, I looked more carefully at your June issue. What finally sold me was the high technical level and large dose of humor in Susan Glinert-Cole's article, "Instant Gratification" (June 1984, page 129).

Eugene Amazon
Geneva, Switzerland

SOME BASIC ARGUMENTS

I thought *PC Tech Journal* was a magazine that catered to experienced users until I read "Structured BASIC" (Eliezer Naddor, July 1984, page 161). What Mr. Naddor seemingly fails to realize is that for the last decade computer scientists and programmers have been writing programs in a top-down structure. This means that the first things you see when you run a program are in the top of the source, and as the program pro-

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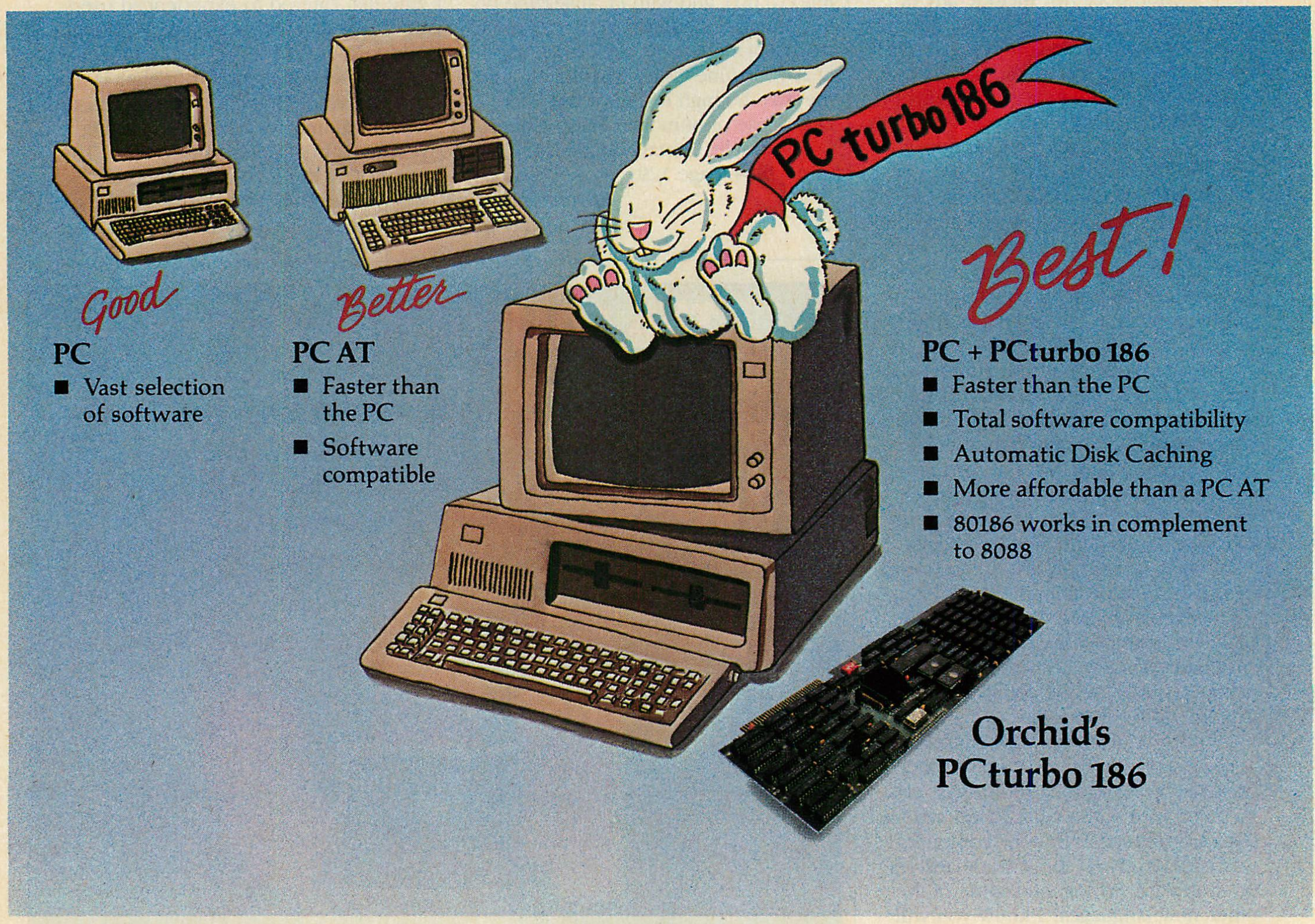

First the standard was the IBM™ PC. Then it became the IBM PC AT with it's high processing speed. For those, however, who have an IBM PC and need PC AT-like performance, Orchid Technology will put you out in front again with a new standard—the PCturbo 186. The PCturbo outperforms the PC AT in speed with fast disk access, and unmatched performance while providing **complete software compatibility.**

Best of all, PCturbo allows you to protect your existing hardware and software investment without the cost of replacing your existing PC or the need to learn to use a new computer and its software. **Simply install the PCturbo adapter board and Orchid's "Productivity Software" and your PC becomes a powerful turbo-driven computer.**

The PCturbo 186 is actually a second computer within your PC. Powered by the advanced Intel 80186 processor, the PCturbo is transparent to your favorite programs like Lotus 1-2-3,™ Symphony,™ dBase II or III,™ Framework™ and Multimate,™ running them at turbo speeds. **So, with PCturbo, your PC looks and acts the same as before; it just runs faster.**

While the PCturbo is speeding up your processing power the 8088 microprocessor in your PC takes care of the I/O functions. Most importantly, complete compatibility is assured since the PCturbo allows you to switch back and forth between Turbo Mode and PC Mode with a simple command.

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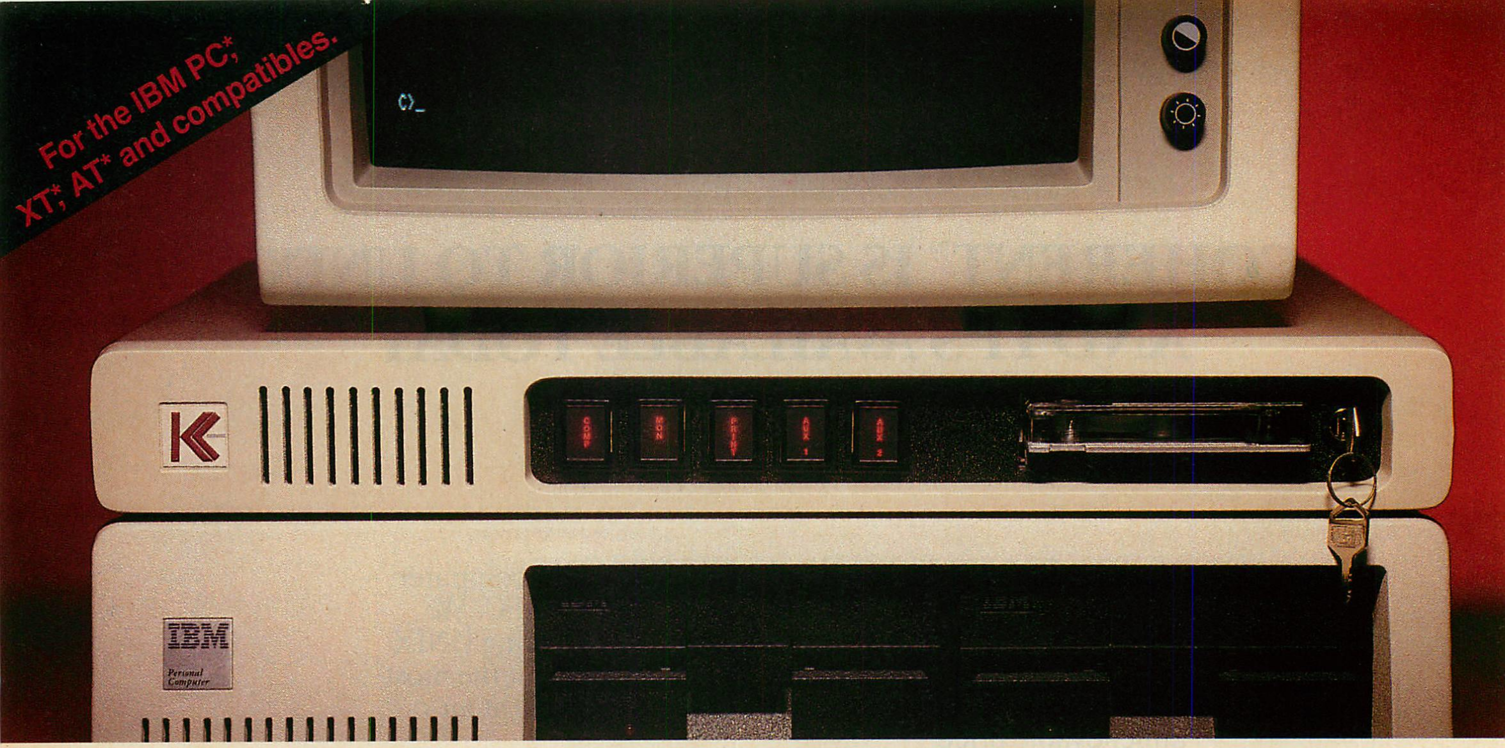

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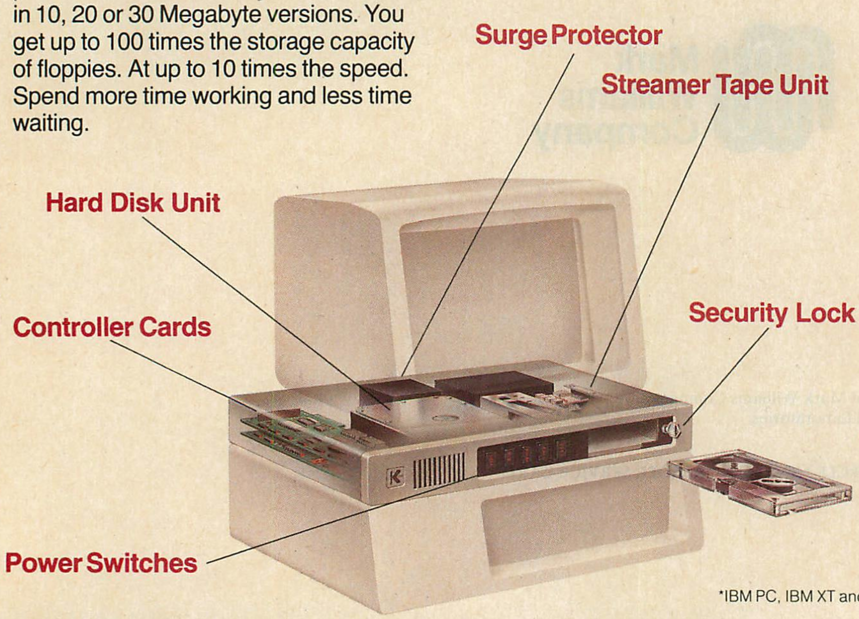

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gresses, so does (generally) the source. Mr. Naddor looks like he is following protocol until line 600. Then he adopts a "from the middle, out" syndrome.

He states that his methodology is suited for small as well as large programs, but then claims that he does not use line numbers larger than 9999 because he finds it confusing. With his limited structure, he only allocates 39 program lines. I couldn't write a calculator program in 39 lines, not to mention a database or inventory program.

Then he says all of his variables are single-lettered and documentation is external to the program to save "valuable space." Maybe he forgot to read his compiler manual that says all REM statements are taken out of the object code.

The only application I would even consider using his language for is a short program that I would be the only person ever to use. Then, maybe I could wade through my own shorthand. But it seems APL is so much better suited for that purpose with high-order math and short notations that I wouldn't consider stooping to BASIC.

Scott Packard
Orange, CA

Mr. Packard's letter clearly shows that he did not read my entire article, nor did he bother to review a previous one I wrote, which was cited ("After BUBBLESORT: Sorting Methods and Timing on the PC," April 1984, page 40).

First, let me ask Mr. Packard to read again my article on "Structured BASIC." He will see that my programs do indeed follow top-down structure, that my line numbers are in steps of two and five (e.g., page 57), and that I do use variables longer than single characters (though not very long ones).

Mr. Packard also ignored completely the remarks I made about documentation. I clearly stated that in my opinion the documentation of a program should not be within the program but in a separate file or files containing the following: the source code, with one statement per line; remarks in normal English text (with no line numbers); definitions of all important variables; cross-references for every variable, keyword, and line number; and illustrations of input and output.

And I do practice what I preach. Many PC Tech Journal *readers requested documentation on program SORTER. These are the files they received: SORTER.BAS (237 lines, 8,940 characters); SORTER.ASC (ASCII version of SORTER.BAS, 10,624 characters); SORTER.HLP (HELP and EXAMPLES*

messages, 104 lines, 3,840 characters); SORTER.REM (121 remark lines, 3,456 characters); SORTER.DOC (a paginated document based on SORTER.ASC and SORTER.REM, with 507 separated statements and all FOR...NEXT statements clearly marked, 29,312 characters); SORTER.REF (cross-references including one user-defined function, six string arrays, four number arrays, 27 string variables, 55 number variables, 37 keywords, and 92 lines references; 10,496 characters); SORTER.OUT (input/output illustrations, 8,647 characters).

These files were produced by special general programs, which can be used for documenting any structured BASIC program. I do believe that the time has come for all programs to be documented in this way.

—Eliezer Naddor

STRINGS ERROR

The programming examples that you publish can be very useful to readers who are not computer professionals. However, this valuable service can become a disservice if the published examples will not execute properly when they are tried.

This is the case with one of the examples in "Strings" (Christopher L. Morgan, September 1984, page 111). In a listing on page 114, a JCXZ instruction should not be used following a SCASB if its purpose is to test equality or inequality, because it only reflects the status of the residual iteration count in CX, *not* the result of the SCASB. The JE or JNE instruction should be used to test the scan result.

In this particular example, one-byte substrings at the end of a string would not be found. This may seem to be a trivial error; however, would you trust a program that could find all occurrences of the preposition *the*, but missed some occurrences of *a*? I certainly would not.

David McManigal
Stormville, NY

Oops, I did indeed goof. I am including here a correction for this error and another closely related error that also occurs in this program.

Replace the first line containing a JCXZ instruction by:

jne strsearch2 ;quit if found no match

This line follows the line containing REPNZ SCASB.

In addition, the second line containing a JCXZ instruction should be replaced by:

je strsearch3 ;string match if all chars match

This line follows the line containing REPZ CMPSB.

I was well aware that the JCXZ instruction tests the "residual iteration count." However, I mistakenly thought that that's what I wanted to do. I now agree that the Z flag gives the proper answer, and therefore JE or JNE should normally be used after such a repeat loop. To resolve this issue, I found it helpful to make the truth table (shown below), which clearly lays out all possible outcomes after the REPNZ SCASB loop.

In this particular program, I wanted to "jump" only if the third case happened. Since the fourth case never occurs, the condition of the Z flag along properly detects the desired condition. I also made a truth table to check out the second repeat loop, and as a result, made the second correction.

I do not think this error is trivial at all. In fact, I find it rather interesting. I am very sorry for the inconvenience it may have caused you.

—Christopher L. Morgan

THE DISAPPEARING CURSOR

I was most interested to read "PC Power-up Error Codes" in the August issue of *PC Tech Journal* (Jack Wright, page 115). I have had repeated experience with one "symptom" in table 1—namely System does not respond at all when turned on. When this happens to me randomly, I have always found that doing as you say—turning off the power supply, waiting five seconds, then turning it on—always brings up the blinking cursor. I am glad to learn that somebody else must have the same problem.

TRUTH TABLE

Z Flag	CX Register	Explanation
Z	Zero	Match on last character
Z	Nonzero	Regular match
NZ	Zero	No match possible
NZ	Nonzero	Cannot happen

Now I would be curious to know why.

I never have had any problems with the other error codes, but I have one problem you did not mention, and it drives me wild sometimes. Often when I am experimenting with some programming in Assembly or compiled C, while running the program, the system goes off into the wild blue yonder and doesn't come back with Ctrl-Break or Ctrl-Alt-Del. I have to shut the power off and then turn it back on—except that the blinking cursor does not come back on. I always have to wait at least five minutes with power off before I can get the cursor to show up. Sometimes the interval turns out to be as much as 10 minutes.

Based on your obvious knowledge of what goes on in the PC, I wonder if you could tell me why this happens, if it is normal, and if there is some way to speed up this maddening interval.

For background information, my IBM PC has 256KB of RAM on the system board, two disk drives, an Apparat CRAMBO board with an additional 384KB of RAM to total 640KB in the system, and a monochrome adapter board. In addition, I have an Apparat hard-disk system that has its own power supply but with an adapter board plugged into a PC system slot. I have thought that all this load may build up some kind of electrical charge that prevents the power-supply from going into action until that charge dissipates. Any suggestions?

Frank P. Barnes
New York, NY

Problems like yours are always difficult to diagnose remotely, but the following information may be helpful. First of all, your problem is not *"normal" and is very likely not a result of your PC failing any of the diagnostics in the BIOS ROM's power-up sequence. No matter how badly your system crashes, you should always be able to recover by turning the system off, waiting about five seconds, and turning the system on again. You should see a cursor within about five seconds, even though the memory test will not allow you actually to use the system until it has completed. Your problem appears to be related to a characteristic of the PC's power supply. This power supply has, as one of its outputs, a TTL logic signal called* power good. *This signal will not allow the 8088 microprocessor to run until the following conditions are met: the power supply must have been off for at least five seconds, and the DC output voltages must have stabilized within certain minimum and maximum values. For*

the 5-volt supply, the levels are between 4.0 and 5.9 volts; for the 12-volt supply the levels are between 9.6 and 14.2 volts. The power good signal will also stay off if the power supply current exceeds 130 percent of its rated capacity.

Perhaps there is some interaction with your separate hard-disk power supply that is interfering with these levels (thus keeping the power good signal off), or there may be a problem in the power supply itself. I have had no experience with your particular hard-disk configuration, but it may help to turn on the PC first, then *turn on the hard-disk supply. You can test whether the problem is related to the hard-disk system by removing that adapter card for a day or two and checking to see if the problem persists.*

As a partial solution to your "wild blue yonder" problems, a common problem among assembly language programmers, a firm called Security Microsystems has enhanced its QUICKON *"fast-bootup" module to provide a way to recover quickly from the keyboard freeze-up condition you described,* with-out *turning off power. The device is now called* PC RESET, *and the company can be contacted at 16 Flagg Place, Staten Island, NY 10304, 212/667-1019.*

—Jack Wright

FULL-LINE LISTINGS

Your program EPSON.COM was greatly appreciated, and I am sure that it will see much use ("The DOS Command IBM Forgot," Douglas Ritari, September 1984, page 79).

Perhaps you can answer a question that has bothered me for some time. When I assemble a program and list it using the procedure outlined in the Macro Assembler manual, my printer prints only 80 columns wide, due to the fact that it is copying the screen, with the result that my listing looks nothing like yours and is awkward to read. This is in spite of the fact that I have set the printer to 132-column width.

How can I get assembly language program listings that print the full line as it appears in your listing?

Sam Starr
Rose Valley, PA

The second line of the EPSON.COM program contains the PAGE pseudo-op. This command is used to set the length and the width of the assembly listing pages. The listing defaults to 66 lines per page, with a page width of 80 columns (regardless of what your printer is set to) if the PAGE statement is omitted from the program.

The PAGE command does not take effect until it is encountered in your source code, so be sure to have it in one of the first few lines of your program. See page 5-75 of the IBM Assembler Manual *for further details.*

—Douglas Ritari

MULTI-OPINIONATED

We at The Software Link were very pleased to see your review of our product, MultiLink, in the October 1984 issue of *PC Tech Journal* ("Multitalented," J. Eric Roskos, page 64):

It is nice to know that reviewers of the caliber of Mr. Roskos are still around, and that they are willing to review the product on its own merits and not according to some fixed set of standards commonly applied to anything that happens to be software. We applaud you for your fine journalism.

Many of your readers might be surprised to learn that MultiLink has been around for almost two years. The first copies were sold in January 1983; since then, the product has been steadily maturing and improving. It has acquired a following among the more "expert" PC users, while receiving little notice from the press until recently.

I would like to comment on a couple of things in the review.

First, Mr. Roskos correctly notes that because PC-DOS was not designed to be multitasking, echoing of keyboard input is not always as fast as the user may desire. However, MultiLink does contain logic specially designed to alleviate this situation in that a task waiting for keyboard input is temporarily assigned a higher-than-normal priority at the instant the keyboard data are received. This logic can be defeated in certain situations if the MLUTIL DIS function is not applied when appropriate. I mention this mainly to point out that what may initially appear to be a performance problem with MultiLink can often be resolved by carefully applying some special feature.

Also, the problems regarding the cursor and the IBM prototype board have been fixed. These and other fixes are available from our technical support staff and also from our bulletin board system, which was recently upgraded to support two telephone lines (incidentally, anyone can gain limited access to the bulletin board; the telephone numbers are 404/457-4784 and 451-7180).

Finally, I must take exception to the author's comments regarding our pricing. Many of our customers are amazed that we charge so little for multi-user capability. The article failed to mention that we offer a 30-day, money-back guarantee on MultiLink. This gives the customer 30 days to evaluate the performance of MultiLink risk-free.

We are announcing a brand-new product called MultiLink Advanced that was developed specifically to take advantage of the powerful features of the IBM AT and of DOS 3.0.

Rod Roark
The Software Link
Atlanta, GA

It seems surprising that J. Eric Roskos did not mention a multitasking product very similar to MultiLink in his October review. I have used MultiJob for almost a year, and consider it superior to MultiLink in several aspects:

- MultiJob allows separate purchase of the multi-user print spooler and memory disk options, so the base product, which is multitasking/single-

A BUREAUCRAT'S GUIDE TO WORD PROCESSING

Now, if it were you or I and we wanted a word processing program for our IBM-type PC, we'd probably stop off at our local computer store and simply diddle with a few.

You and I, however, are not the U.S. Department of Agriculture.

(Nor any of its permutations of subsystems like the Economic Research Service, National Resources Economics Division, Data Services Center, etc., etc.)

So when the USDA told ERS to tell NRED and DSC to look into a truckload of w.p. programs for all their PCs, the last thing they wanted was simple diddling. Their dedicated Wangs and Lexitrons were far too few to handle their needs, their IBM® PCs weren't compatible with them anyway, and nobody really, quantifiably, knew from word processing with a personal computer.

Definitely not a diddling-mode condition.

As they put it in The Exchange, an internally distributed publication of the Department of Agriculture: "A needs assessment showed that, in the long-term, a word processing system is needed that can increase word processing capability and also be compatible with ERS' Long Range Information Management goals."

Well. "Needs assessment" led swiftly to "procurement action," which galloped into an "objective review" of the eight top-rated PC programs on the market (as compiled by The Ratings Book published by Software Digest), along with Wordstar® and Display Write 2, because they had some around.

THESE ARE THE PACKAGES THE COMMITTEE EVALUATED:

Thus armed with the names, the final evaluators (a team of secretaries from NRED who would be the primary users of the PC software) became armed with each of the programs, along with checklists to record such things as ease of use, advanced features, and similarity to their existing dedicated equipment.

The first to be eliminated from the prospect list were Office Writer™ and Samna,™ since they're copy-protected and couldn't be transferred to hard disks.

Next, IBM's Display Write 2: because it's "not compatible with other software used in ERS (like Lotus 1-2-3,™ dBASE II,® etc.)," and it's "full of confusing menu options and cryptic error messages." Au revoir IBM.

Then, three more, for a variety of reasons.

Which left the following:

Volkswriter® Deluxe™
MultiMate™
Leading Edge™

Volkswriter Deluxe? "Too complicated and confusing." Not "easy to learn or use."

MultiMate? Not bad. It actually tied the winner in a few categories.

The winner being the one that won 82% of the votes in the Ease of Use/Ease of Learning categories. The one about which they said, "The ability to store deleted text and automatic document backup features were both highly desirable." The one they thought they'd quickly "be able to use . . . for their day-to-day word processing tasks."

The whole process took some three months of work by people in DSC to support the NRED in its work with the ERS and DSC to make the world a better place for the USDA.

But the results were well worth the wait. Because at last they've solved their word-processing problems . . .

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user, is less expensive—about $150.

- MultiJob allows the time-sharing algorithm to be tuned. For example, I gave my compile/text partition 75 percent of the available cycles, leaving the editing partition with the balance. Further, MultiJob appears to be sensitive to keyboard activity, as it seems to shift priority to the editing partition to give better response when I blaze away at the keyboard. I like this self-tuning as I alternate between "think" and "key" work states.
- MultiJob allows the background partitions to be temporarily stopped with a keystroke. This eliminates the time-sharing overhead completely when the user desires.
- MultiJob also "shadow prints" the background screen, so DOS messages are not necessarily lost. Alternatively, a keystroke can cause the background task that needs to print to the screen to suspend execution until it becomes the foreground partition.

Roskos' description of MultiLink is so similar to the MultiJob I am familiar with I called B & L Computer Consultants, the developers, to see if these two products were the same. I was assured they are not, but are in fact competing products. Closer reading showed this to be the fact, as MultiJob does not exhibit the file limitation nor the prototype board problem. I also found the B & L will be releasing a new version of MultiJob to support DOS 3.0—very good news indeed, as I am completely hooked on multitasking as a productivity aid for program development, and expect to upgrade to 3.0 shortly.

Chet Floyd
Manhattan Beach, CA

LISTING BY TELEPHONE

I am happy to see that *PC Tech Journal* offers readers a way of obtaining the source code listed in its issues. This service can be very beneficial to readers.

However, I would like to suggest that you use a different method of source code distribution. One magazine I subscribe to gives its subscribers a telephone number. The subscriber can use this number to connect to the magazine's bulletin board system, and then download any particular source code contained in the last three issues.

I believe that this method of source code distribution is preferable to the method that you are using. I would much rather type in the code than pay $20 and still have to wait four to six weeks. You might not make as much money doing this, but believe me, it will make loyal subscribers.

Doug Sharp
Systems programmer
Arvin Industries
Columbus, IN

We have considered this. However, a user could easily run up a telephone bill of more than $20 using such a service—especially if there were telephone-company-induced transmission errors or the like. In short, we can guarantee a diskette, but not a telephone line.

I would be interested in knowing how others feel about this.

—WF

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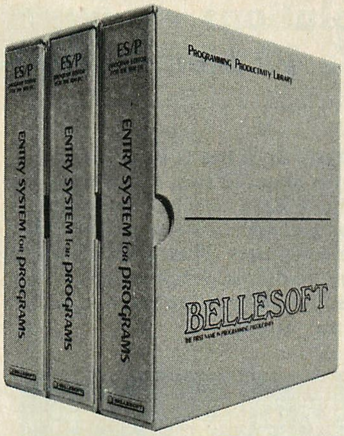

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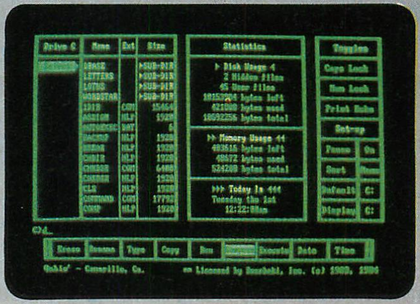

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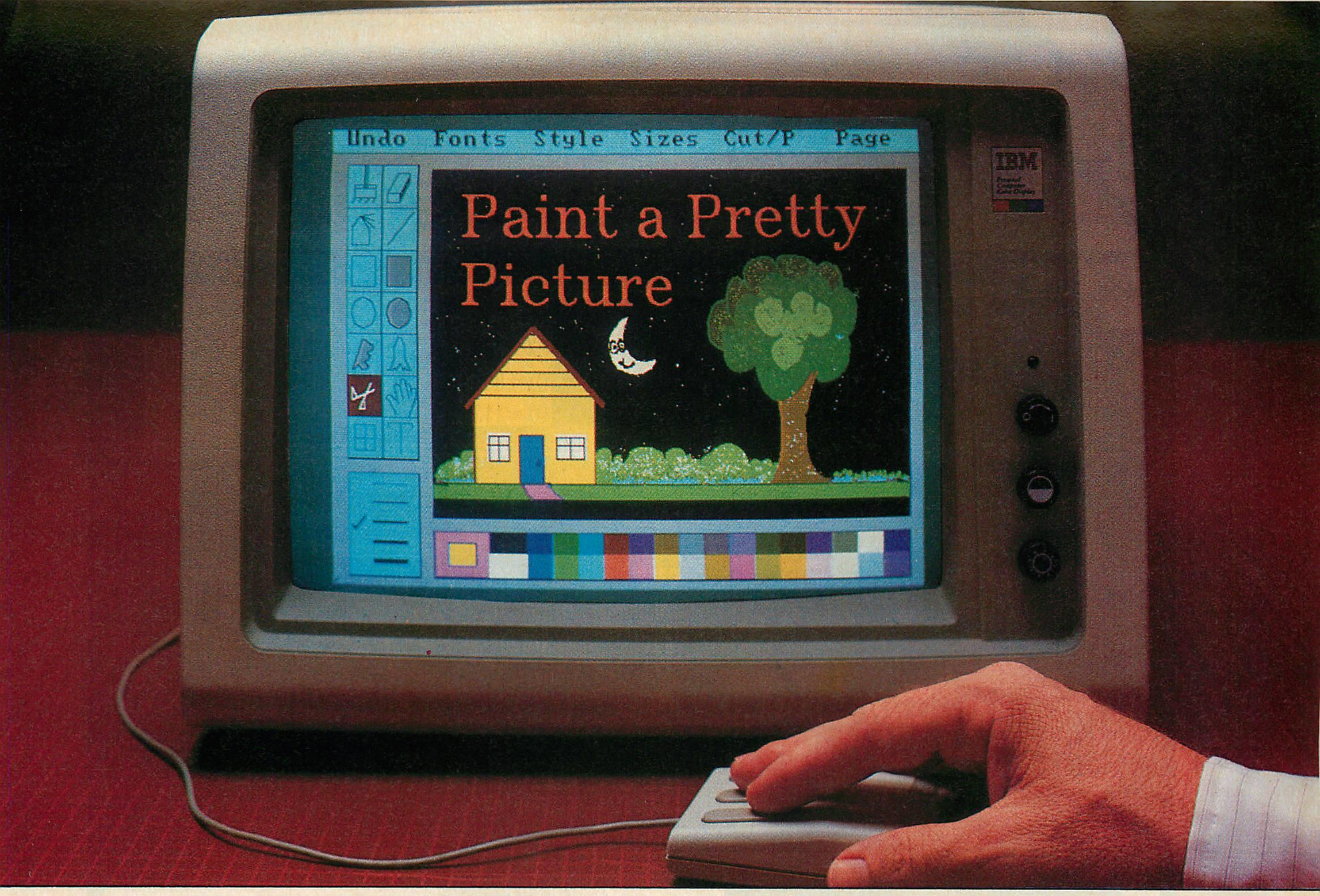

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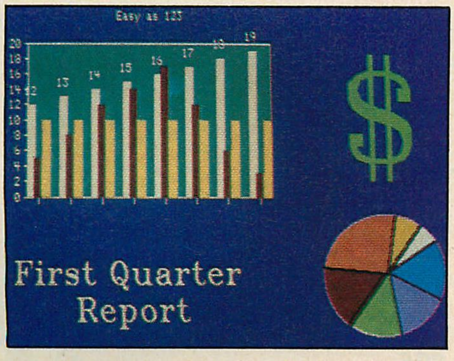

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                                              CX=0000     SI=0000     ES=1985
                                              DX=1138     DI=0000     CS=2001
                      PL ZR  NC NV  UP  NA PE  EI                     IP=0001
2001:0000    53                  24 IO_INIT:  PUSH   BX                         ;TAG A LINE
2001:0001    9BDEC2                           FADDP  ST(2),ST
2001:0004    BB3100                           MOV    BX,Offset VECTOR_TABLE_2
2001:0007    803E5E~             34           CMP    DOS_VERSION_NUM,'2'        ;BREAKPOINT SET
2001:000C    7305                             JAE    TRASH_IT
2001:000E    BB0100                           MOV    BX,Offset VECTOR_TABLE_1
2001:0011    EB02                             JMP    Short LONG_LABELS_ARE_OK_AS_YOU_LIKE
2001:0013    F2AB     00777      TRASH_IT:    REPNZ  STOSW                      ;STOP 777th TIME
2001:0015                        LONG LABELS_ARE_OK_AS_YOU_LIKE:
2001:0015    8DAD63-                          LEA    BP,WIERD_CODE + 2[DI]
2001:0019    240C                             AND    AL,00011100B               ;CHANGE RADIX
2001:001B    45                               DB     69
                           MEMORY DUMP
>>DOS_VERSION_NUM               Absolute Address=03C9E    Segment:Offset=03C4:005E
1984:0050   41 53 43 49 49 20 53 55-50 50 4F 52 54 20 32 20   ASCII SUPPORT 2
1984:0060   20 2D 2D 20 43 6F 64 65-53 6D 69 74 68 2D 38 36    -- CodeSmith-86
1984:0070   20 4D 41 4B 45 53 20 44-45 42 55 47 47 49 4E 47    MAKES DEBUGGING
1984:0080   20 41 20 42 4C 41 53 54-21 20 20 20 20 20 20 20    A BLAST!
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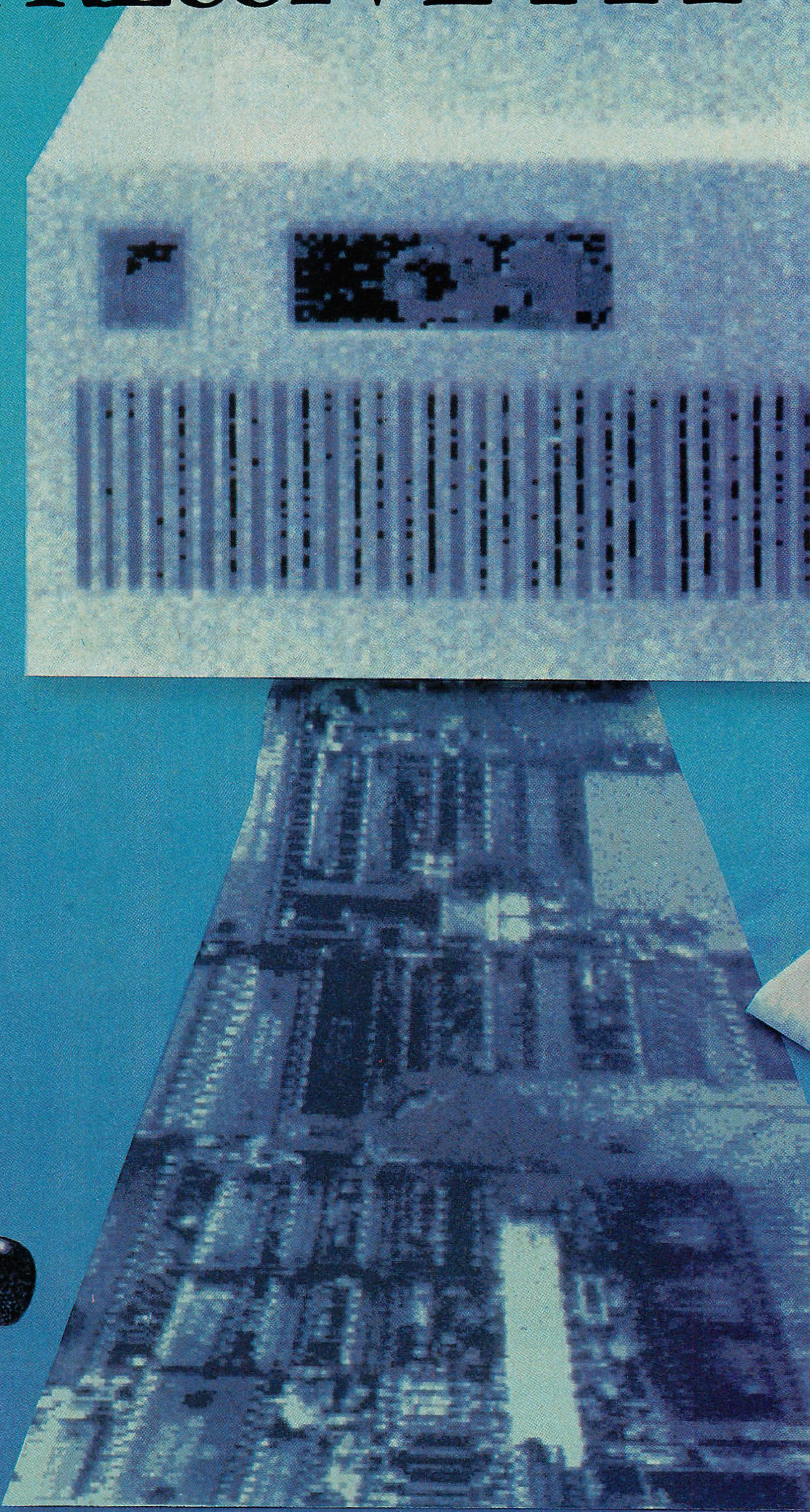
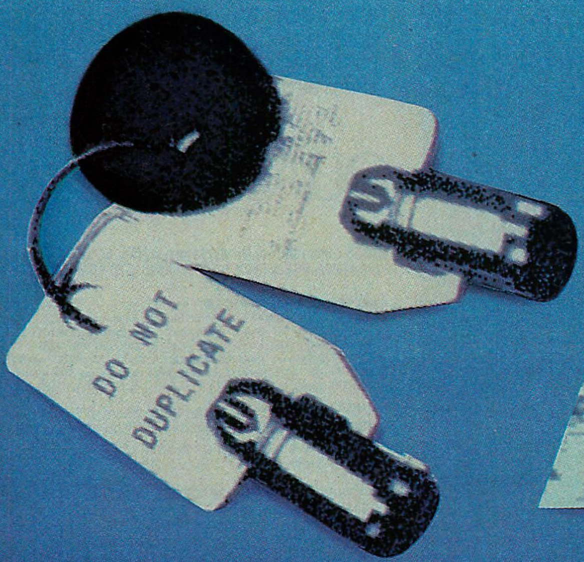


One word describes our first reaction to the IBM Personal Computer AT: impressive.

Impressive because IBM built a whole new machine from the ground up that is amazingly compatible with machines we already know and love, the PC and the PC/XT. Impressive because it gives us true multitasking and true networking.

We did not stop assessing the AT until we understood it from the outside in and the inside out. Our first impression held and intensified: we are now even more impressed.

In this special report on the AT, a complete technical review is followed by coverage of the major elements that contribute to the AT's power: DOS 3.0, the IBM Network, the iAPX 286, and XENIX. The report details the research behind our impressions of the fastest and most powerful microcomputer yet in the IBM family of personal computers.



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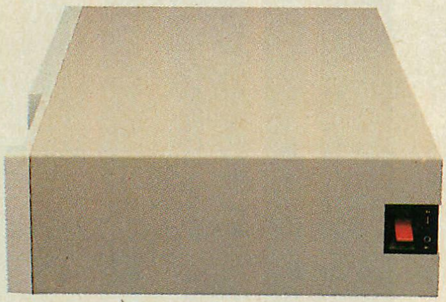


Analyzing the Advanced Technology

A technical review of IBM's fastest, most powerful, and most advanced Personal Computer

THOMAS V. HOFFMANN

The PC/AT is not the best, fastest, most powerful, most advanced desktop computer in the world, but that is not the issue at hand.

ADVANCED TECHNOLOGY APTITUDE TEST

Part 1: Comprehension. Read the following passage, then answer the questions below. Multiple choice questions may appear to have more than one correct answer; try to pick the *best* one. A general familiarity with Western Civilization since 1950, while not an absolute prerequisite, will be quite helpful.

After the anthem, the Atlanta team accepted the accolades thrust at them as the avid throng anticipated this, another test, and the Astros thoughtfully admired three awfully tense and thoroughly artful throws along the artificial turf. Alfredo talked animatedly, then absentmindedly took another Twinkie, almost thoughtlessly, and that annoyed Tom Adams. "That artless twit! Always talking, always taking. A totally artless twit," Adams thought. Alfredo tossed a towel at the Astros' trainer, Artie, then Artie took a Twinkie. Adams tensed. A tiny accident tonight and their aspirations tumbled: Atlanta threatened, and trepidation affected them all terribly. Adams thought all the athletes tired and thin. Artie took all the Astros' towels and threw Alfredo's Twinkies away. "Terrific! Another temper, another tantrum, and then Atlanta takes all," threatened Adams. "Terrific!"

1. IBM's new personal computer is
   a. In a league by itself
   b. Where it's at
   c. Where it sat
   d. Wear its hat
2. Says who?
   a. The passage I just read
   b. The *Wall Street Journal*
   c. The cover of this issue
   d. Artie

Thomas Hoffmann wrote the technical review of PCjr in the May issue of PC Tech Journal *and last month compared ten, 10MB fixed-disk systems. He is a contributing editor to this magazine.*

3. The ballgame is
   a. About to begin
   b. A whole new one
   c. Metaphorical
4. *Twinkies* are a metaphor for what?
   a. Peanuts
   b. Hot Dogs
   c. Popcorn
   d. Nachos
5. *Accolade* means:
   a. Good, like an accordian
   b. A drink served from a smiling pitcher
   c. Pitchers never smile during a game
6. The passage is structurally similar to
   a. The pancreas of a Malayan jungle lemur
   b. The ROM subsystem of the computer in question 1
   c. Alvin Toffler
   d. Nothing in Western Civilization since 1950
7. The only serious question is
   a. This one
   b. Question 1
   c. Question 6
   d. What is truth?

STOP. Do not proceed until told to do so. Do so. Now.

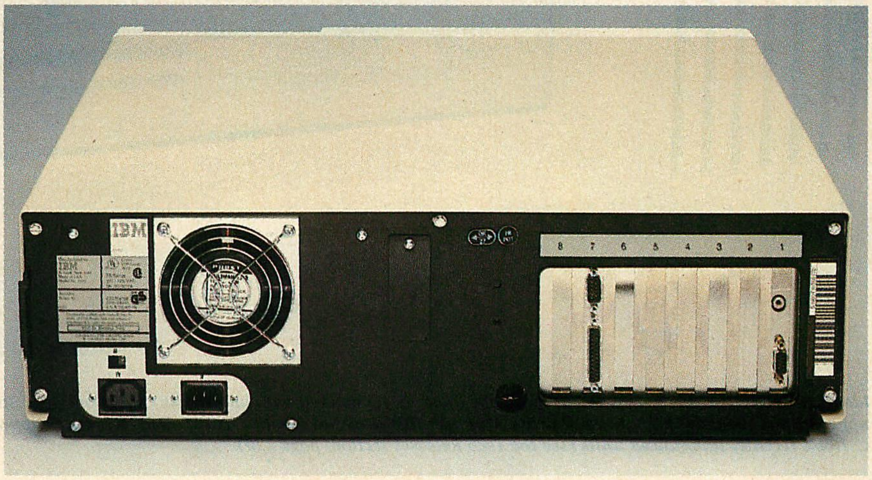
TIMING IS EVERYTHING

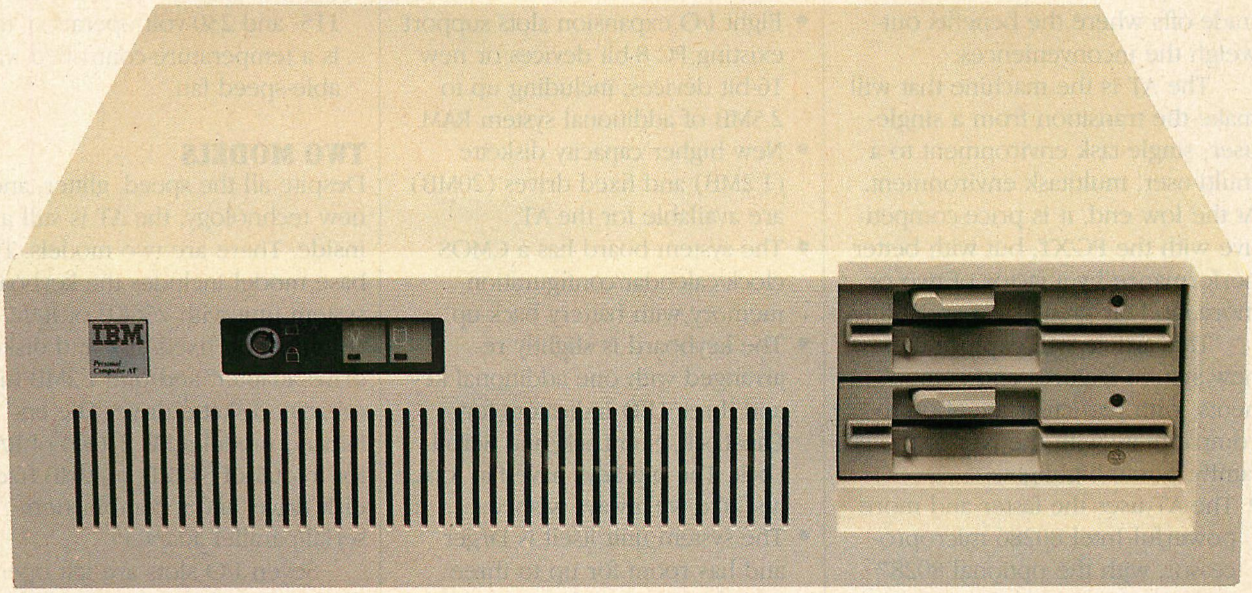
In literature, as in life, the questions often are more interesting than the answers. Unfortunately, I will never get away with (or paid) writing an article that is completely devoid of answers, so here we go with yet another question: Wanna by a duck?

How about a paradox? (I know, that's two questions. Actually, it is two ducks, but who is counting?) Douglas Hofstadter fans will certainly enjoy question seven, the answer to which should be (c) Question 6, because the answer to question six is (b) The ROM subsystem of the computer in question 1 (I'll explain why later), but that makes question seven also serious, so (a) is correct, but the question is "The *only* serious question is." Therefore, this statement is false.

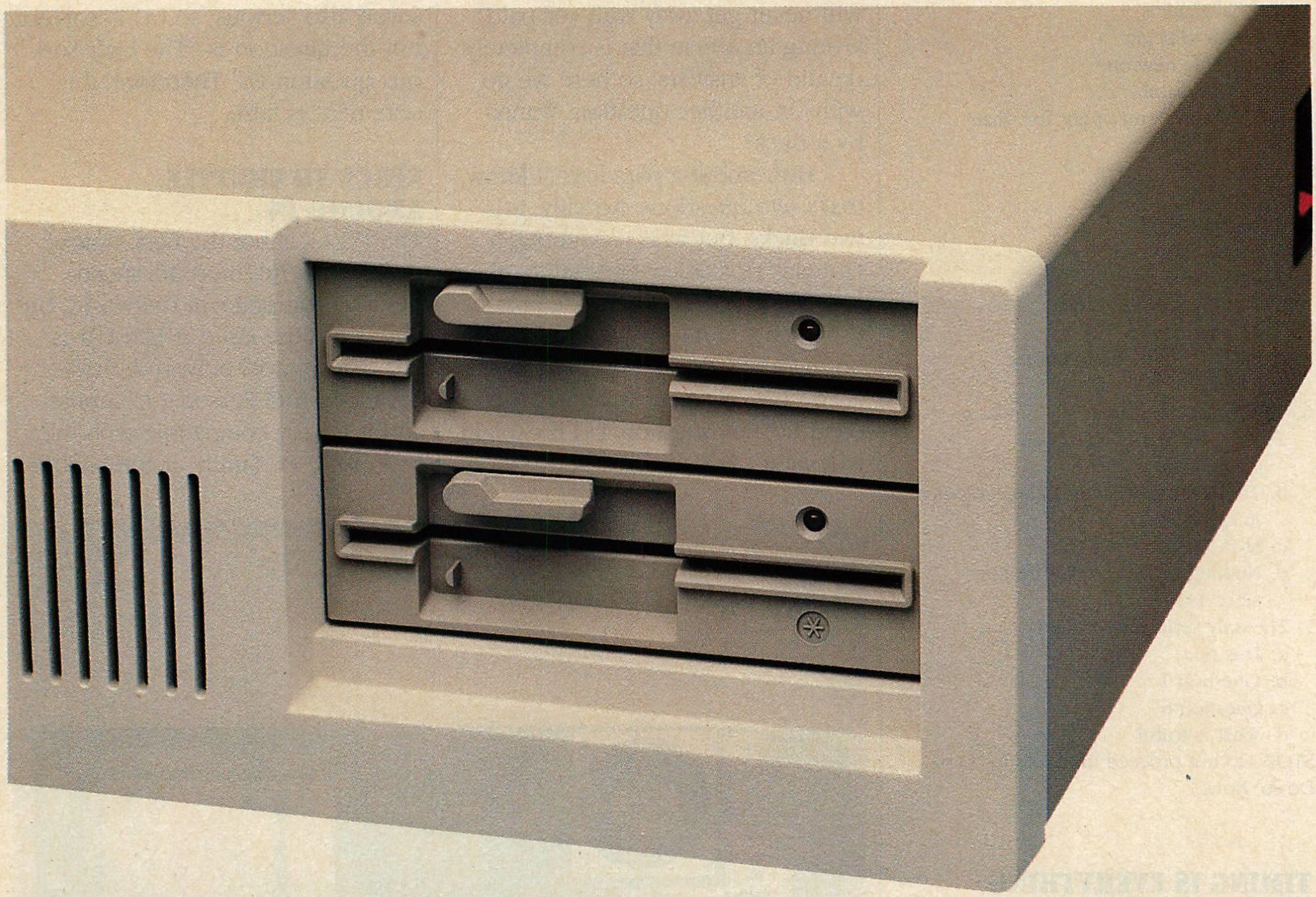
SPACE TO SHUTTLE AROUND IN

The PC/AT is not the best, fastest, most powerful, most advanced desktop computer in the world, but that is not the issue at hand. It is the fastest, most powerful, most advanced IBM Personal Computer, and it is very compatible with the rest of the PC family; incompatibili-





The AT sports a boxier and less stylish look than its predecessor. It is most obviously different when observed from the front, with its keylock, indicator panel, and half-height diskette drives. From the side and back, however, a closer look is required to distinguish an AT from a PC.



Identical-looking diskette drives? Not quite: the lower unit (marked with an asterisk) is the optional 360KB drive; the upper unit is the new "high density" drive. Although IBM does not identify its suppliers, the drives appear identical to C. Itoh's recently announced units (see the Tech Releases section, page 220).

ties are generally due to conscious trade-offs where the benefits outweigh the inconveniences.

The AT is the machine that will make the transition from a single-user, single-task environment to a multi-user, multitask environment. At the low end, it is price-competitive with the PC/XT, but with better performance by a factor of two or more, and far greater expandability.

This article will explore the new system features and components, with particular attention to compatibility with the rest of the PC family. Some highlights:

- The AT uses the faster and more powerful Intel 80286 microprocessor, with the optional 80287 numeric coprocessor.
- The system board supports 256KB or 512KB of RAM, and 64KB of ROM with sockets for another 64KB.
- Eight I/O expansion slots support existing PC 8-bit devices or new 16-bit devices, including up to 2.5MB of additional system RAM.
- New higher capacity diskette (1.2MB) and fixed drives (20MB) are available for the AT.
- The system board has a CMOS clock/calendar/configuration memory with battery back-up.
- The keyboard is slightly rearranged with one additional key and three LED indicators for CapsLock, NumLock, and ScrollLock. The big keys have flat tops, just like we always wished.
- The system unit itself is larger and has room for up to three rotating memory drives, with a maximum of two fixed-disk drives or two diskette drives.
- The 192-watt power supply can be switched by the user between 115- and 230-volt operation; there is a temperature-controlled, variable-speed fan.

TWO MODELS

Despite all the speed, glitter, and new technology, the AT is still a PC inside. There are two models. The base model includes the keyboard, system unit with 256KB of RAM, the combination fixed-disk and diskette drive adapter, and one 1.2MB high-capacity diskette drive. The enhanced model adds 256KB of RAM for a total of 512KB, a 20MB fixed-disk drive, and a combination serial/parallel adapter.

Seven I/O slots are left open in the base model and six in the enhanced model. A complete system requires the addition of the user's choice of display adapter and dis-

play. The same adapters that work in the PC will work here; BIOS supports both the monochrome and color/graphics adapters.

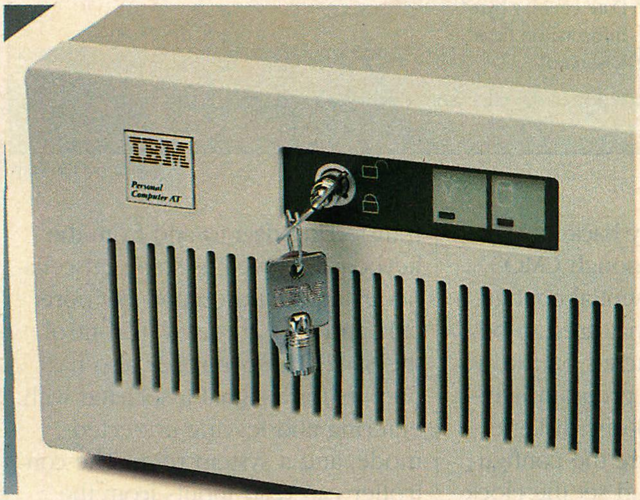
THE PROCESSOR

Intel's 80286 is the most powerful member of the 8086 family, which includes the 8088 used in the other IBM Personal Computers. (See related article, "Evolution of the iAPX 286," by Bob Greene, page 118 in this issue.) It can address up to 16MB of physical memory, runs at a conservative 6 MHz clock rate, has a true 16-bit data bus interface, and its instruction set is upwardly compatible with the 8086 family.

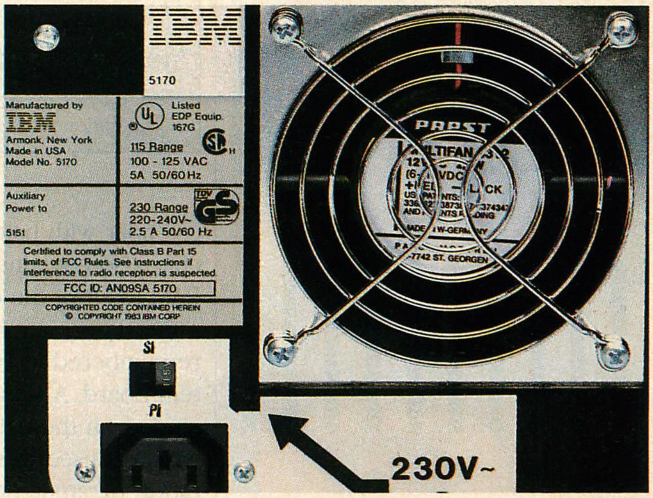
- An Intel 80286 microprocessor and support circuits
- A socket for an Intel 80287 numeric coprocessor
- 256KB or 512KB of RAM, with parity checking
- 64KB to 128KB of ROM
- Seven DMA channels: four 8-bit and three 16-bit channels
- Two 8259A interrupt controllers that provide 15 levels of interrupts, plus NMI
- An 8254-2 counter timer that provides three programmable timers
- A system clock/calendar/alarm and CMOS memory for storing system configuration information, with battery back-up

AT. For the intensely curious, the changes that have been made in the AT include the following:

- Pin B04, which was IRQ2 in the PC, is now IRQ9. The vector is redirected by BIOS to INT OAH, which is where IRQ2 went in the PC and PC/XT.
- Pin B08, reserved in the PC, is a zero wait state signal, which a device can use to tell the processor to complete the present bus cycle without any additional wait states.
- Pin B19, previously DACK0 and used for refreshing the system RAM, is now a bidirectional refresh signal. The system generates refresh without using a DMA



The keylock on the front of the AT system unit is perhaps its most identifiable feature. Locking the system with the keylock secures the cover, disables the keyboard, and prevents a bootstrap.



The AT is delivered with a label covering the power receptacle that reminds the installer to set the power switch for either 115V or 230V power. This means that the same AT system unit can be sold both in the United States and internationally; the PC, on the other hand, required a different model for overseas distribution.

The 80286 processor has two execution modes: Real Address Mode, which supports the existing 8086 architecture with a 1MB memory address space (20 address bits); and Protected Virtual Address Mode, which expands the memory space to 16MB (24 address bits) and has features to support memory protection, virtual addressing, and multitasking directly in hardware.

FAMILY TIES

The system board of the PC/AT packs a lot of function into a space of about 12 by 13 inches. The major components are these:

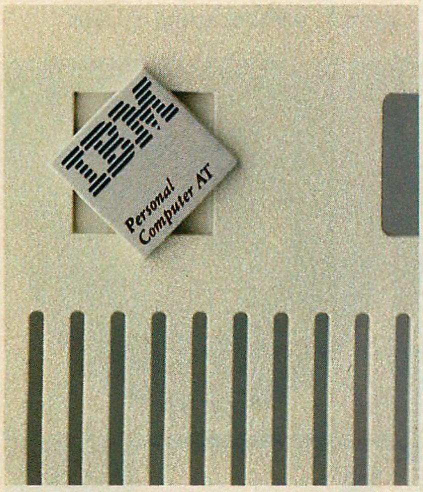
- A speaker
- An Intel 8042 single-chip microcontroller that provides the bidirectional keyboard interface and other sense and control functions
- Eight I/O slots: six that have a 36-pin and a 62-pin edge connector socket; two that have only a 62-pin socket

The I/O channel uses the same 62-pin edge connector as the PC, with essentially the same signals. The few minor differences are compensated for by BIOS, and the result is that nearly all existing PC expansion cards should work in the

channel, and there is a provision for an external processor or other bus master to supply its own refresh signal.

Another 36-pin connector in front of the 62-pin socket supports the additional DMA channels (8-bit channels 0,1,2,3 and 16-bit channels 5,6,7), control and data signals for 16-bit transfers, extended memory address lines, provision for multiple bus masters (other microprocessors), and additional interrupts.

IBM has finally included the second most popular feature (after expansion memory) provided by most multifunction boards: a clock/



The most visible indicator of IBM's attention to detail is the IBM label on the front of the system unit; it can be rotated to any 90-degree position. This means the system unit can be mounted vertically and still look natural, as there are no other orientation clues on the front of the unit.

IBM has finally included the second most popular feature (after expansion memory) provided by most multifunction boards: a clock/calendar with battery back-up.

TABLE 1: *CMOS Address Map*

ADDRESSES	DESCRIPTION
00-0D	Real-time clock information
0E	Diagnostic status byte
0F	Shutdown status byte
10	Diskette drive type byte - drives A and B
11	Reserved
12	Fixed-disk type byte - drives C and D
13	Reserved
14	Equipment byte
15	Low base memory byte
16	High base memory byte
17	Low expansion memory byte
18	High expansion memory byte
19-2D	Reserved
2E-2F	2-byte CMOS checksum
30	Low expansion memory byte*
31	High expansion memory byte*
32	Date century byte*
33	Information flags*
34-3F	Reserved*

* These bytes are not included in the checksum calculation and are not part of the configuration record.

Courtesy of IBM Corp.

calendar with battery back-up. The chip also contains enough CMOS RAM to store the essential configuration information that used to be remembered in switches on the system board. A set-up program is included on the diagnostic diskette, which is used to store the configuration parameters and set the clock. Table 1 shows the layout of the configuration memory.

There are still two switches on the system board: one selects either a monochrome or color display adapter as the initial default display device; the other indicates the presence of the second 256KB of RAM on the system board. A third switch is operated by a key lock on the front panel; it disables the keyboard as a simple security aid.

The timer and speaker logic is compatible with that of the other PC family members. Like the XT, the AT does not have a cassette interface (see table 2).

KEY OF C

The keyboard controller is an intelligent interface, with commands for transferring data to and from the keyboard, as well as some miscellaneous input and output. I/O ports 60H and 64H are used to control the 8042. The controller also has outputs for a signal associated with entering and leaving protected mode, and a system reset. The controller can read inputs from the RAM switch, CRT switch, Key switch, and a manufacturing test jumper.

The major difference between the AT keyboard and the PC keyboard is the two-way data path. The three LED indicators are set by BIOS every time it processes any request for a key or a keyboard interrupt; this ensures the indicators are valid, even if an application changes the shift state bits in the BIOS data area in order to force a particular mode, such as CapsLock.

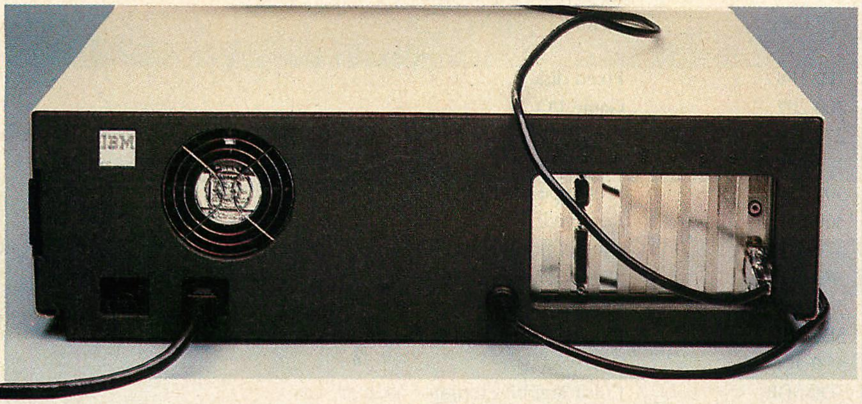
The new keyboard sends the same *make* scan codes (when keys are depressed) as the PC keyboard. The *break* codes are now two-code sequences: F0H followed by the make code. The original keyboard indicated break code by setting the high bit of the scan code. The con-

troller can be told to convert break codes to PC scan-code format before passing them to the system. This allows programs that do direct keyboard input to check the machine ID and set things up so their dedicated keyboard interrupt routines still work. The keyboard interrupt is still INT 9 (IRQ1), and scan codes are read from I/O port 60H, just as in the PC, but the mechanism is different.

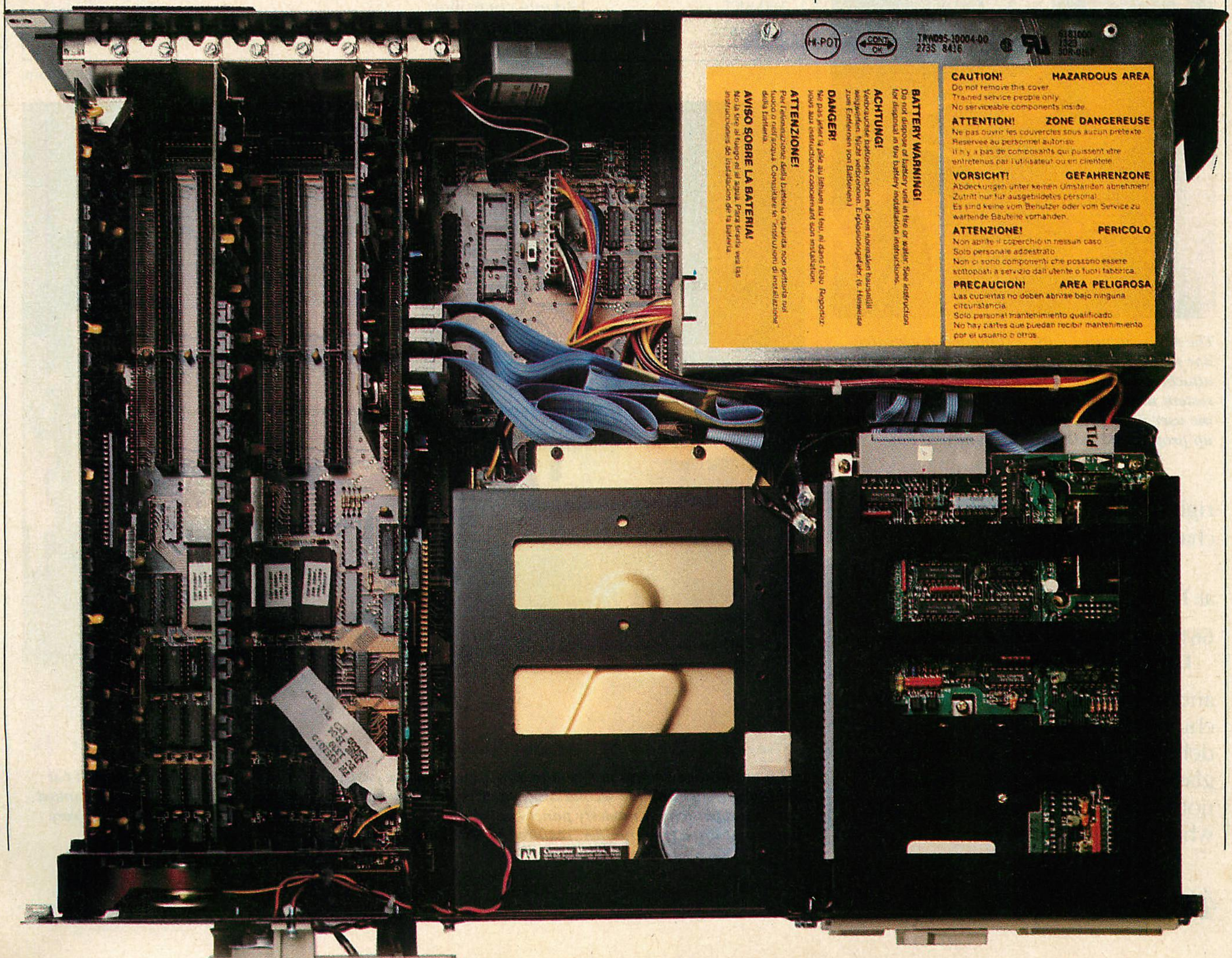
MEMORY ORGANIZATION

The first megabyte of the memory address space (which is all there is in Real mode) is mapped the same as the PC's memory. The first 640KB is available for user RAM (up to 512KB on the system board and another 128KB in the I/O channel). Video buffers, special device BIOS ROMs, and other adapter-resident memory goes from segment A000H up to DFFH. The last 128KB is reserved for ROMs on the system board. The POST (power-on self test), BIOS, and Cassette BASIC occupy the top 64KB of the first megabyte (see table 3).

The new DOS 3.0 operates in Real mode on the AT. This comes as no surprise, because it also runs on every other member of the PC family. The POST places the processor in Protected mode to check that the machine is working correctly and to determine the existence of expansion RAM beyond the first megabyte. Newly added functions in the BIOS allow reading and writing



A modesty panel, supplied with every AT and attached with velcro tabs, dresses up the rear of the system unit. Although the panel does cover some of the gingerbread, wiring can still create a minor rat's nest.

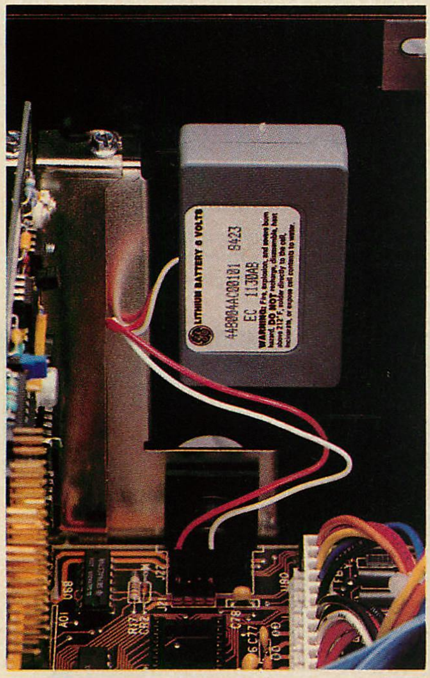


Inside, the AT resembles its siblings. The fixed-disk unit, not visible from outside the unit, is in the center. Eight full-length slots are on the left.

to the extended memory, and the VDISK (virtual disk) driver can be set up to use extended memory as one or more RAM disks. Full use of the extended memory will have to wait for XENIX or other operating systems designed to execute in Protected mode.

ROMS FOR ONE MORE

When someone puts a new IBM PC in or near my hands, my fingers go right for the debugger and start dumping the built-in ROMs in ASCII looking for interesting dates, copy-



The AT is supplied with a standard clock/calendar feature. A lithium battery is also supplied, attached with a velcro fastener to the rear of the system unit. IBM delivers the battery unplugged; the user must attach the battery and run the set-up program to initialize the time and date.

right notices, and other silicon archaeological artifacts.

When I dumped the first ROM at F000:0H, I saw

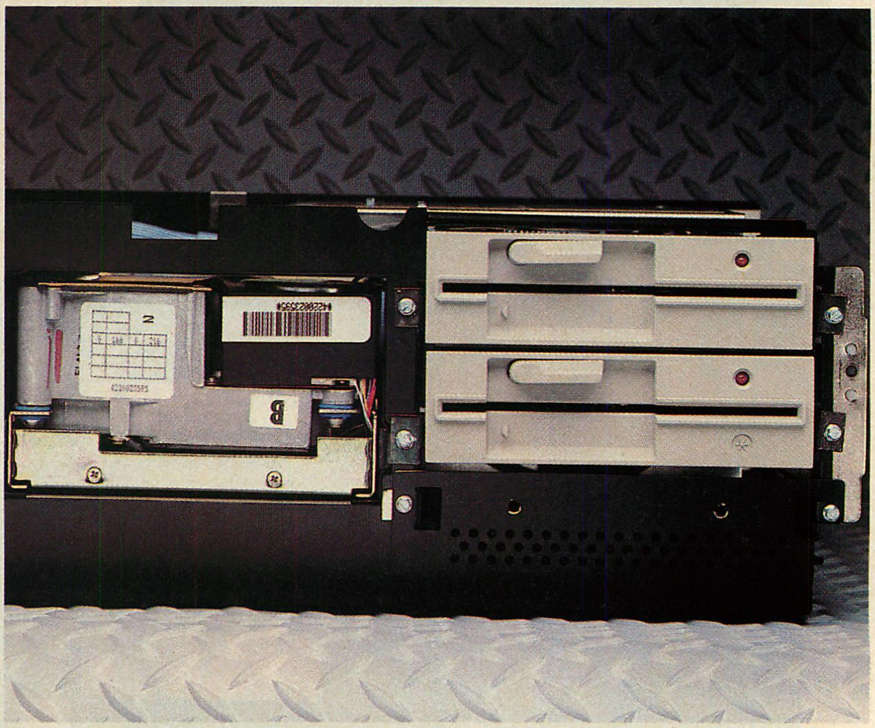
**66118811002289 CCOOPPRR..
IIBBMM 11998844**

and immediately suspected a machine malfunction or a bug in the debugger: I had just gotten new glasses, so I knew my eyes were not failing me. Eventually I realized what was going on. The memory on

TABLE 2: *I/O Address Map*

HEX RANGE	DEVICE
000-01F	DMA controller 1, 8237A-5
020-03F	Interrupt controller 1, 8259A, master
040-05F	Timer, 8254.2
060-06F	8042 (keyboard)
070-07F	Real-time clock, NMI (nonmaskable interrupt) mask
080-09F	DMA page register, 74LS612
0A0-0BF	Interrupt controller 2, 8259A
0C0-0DF	DMA controller 2, 8237A-5
0F0	Clear math coprocessor busy
0F1	Reset math coprocessor
0F8-0FF	Math coprocessor
1F0-1F8	Fixed disk
200-207	Game I/O
278-27F	Parallel printer port 2
2F8-2FF	Serial port 2
300-31F	Prototype card
360-36F	Reserved
378-37F	Parallel printer port 1
380-38F	SDLC, bisynchronous 2
3A0-3AF	Bisynchronous 1
3B0-3BF	Monochrome display and printer adapter
3C0-3CF	Reserved
3D0-3DF	Color/graphics monitor adapter
3F0-3F7	Diskette controller
3F8-3FF	Serial port 1

Courtesy of IBM Corp.

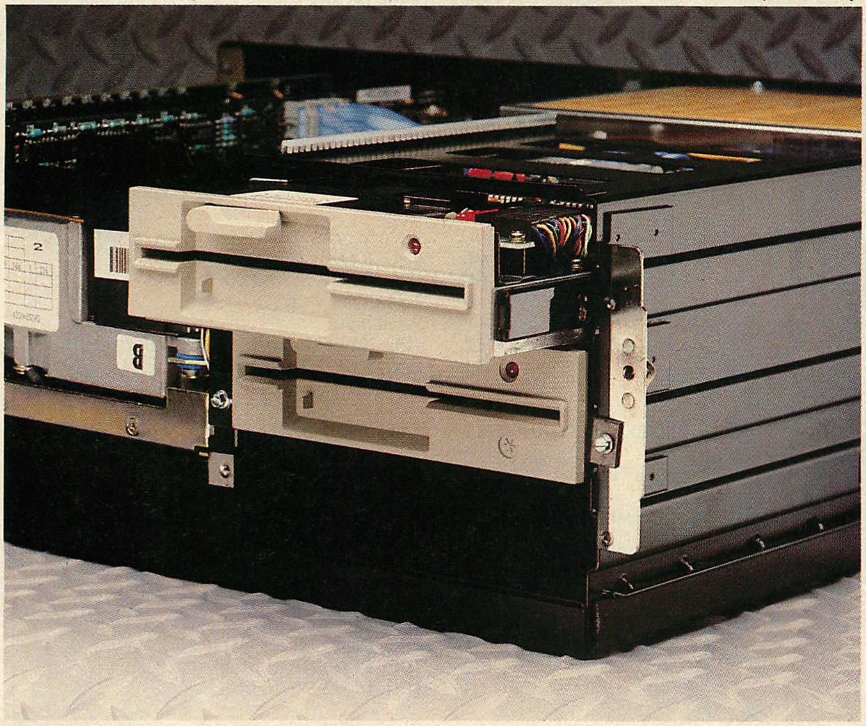


All mass storage devices are mounted in slides and are easily installed and removed. If the grill (at the lower right) and the second diskette drive are removed, a second fixed-disk drive can be mounted and is hidden with a modesty panel (not shown). Note the label on the fixed disk: it shows the very important drive-type number, required by IBM's AT set-up program.

TABLE 3: *System Memory Map*

ADDRESS	NAME	FUNCTION
000000 to 07FFFF	512KB system board	System board memory
080000 to 09FFFF	128KB	I/O channel memory 128KB memory Expansion option
0A0000 to 0BFFFF	128KB video RAM	Reserved for video display buffer
0C0000 to 0DFFFF	128KB I/O expansion ROM	Reserved for ROM on I/O adapters
0E0000 to 0EFFFF	64KB reserved on system board	Duplicated code assignment at address FE0000
0F0000 to 0FFFFF	64KB ROM on the system board	Duplicated code assignment at address FF0000
100000 to FDFFFF	Maximum memory 15MB	I/O channel memory 512KB memory Expansion options
FE0000 to FEFFFF	64KB reserved on system board	Duplicated code assignment at address 0E0000
FF0000 to FFFFFF	64KB ROM on the system board	Duplicated code assignment at address 0F0000

Courtesy of IBM Corp.



Rails are attached to the sides of the disk units. Once installed, the drives are secured with small brackets, such as the one shown on the lower disk drive.

the system board is organized in 16-bit words, but standard ROM and PROM chips are organized in 8-bit-wide bytes. It takes two ROMS side-by-side to make a block of 16-bit memory: the even addresses are all in one chip, and the odd addresses are in the other.

Look again at the ccooppyy-rriigghhtt notice. Each ROM begins with an ASCII identification number and copyright, which if read by itself is perfectly normal. The two interleaved messages give the op art display shown above.

This leads us at long last back to the opening passage of this article, which in case you didn't count, contains exactly 128 words. The even ones all begin with the letter *A* and the odd ones begin with the letter *T* (if you number starting at 0). If each word is said to represent 1KB of system ROM, then the organization of the paragraph is analogous to that of the 128KB ROM space at the AT system board. If you already knew this, you may go to the head of the class.

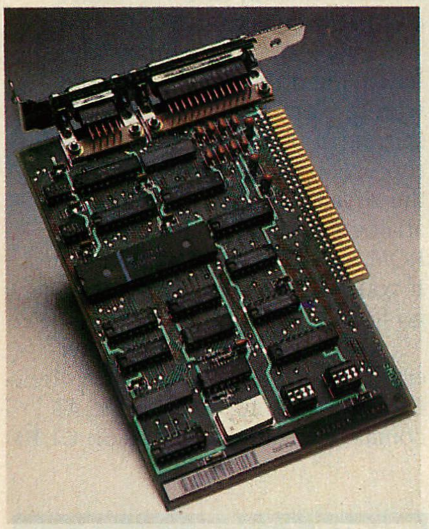
For those of you more interested in function than in form, the 64KB ROMs shipped with the AT contain Cassette BASIC version C1.10

TABLE 4: *PC Family Codes*

PC FAMILY TYPE CODES (IN LOCATION FFFFEH OF SYSTEM)	
FFH	PC
FEH	PC/XT and Portable
FDH	PC*jr*
FCH	PC/AT

(32KB), which is identical to the version shipped in the current PCs. (The PC*jr* has a different version C1.20, which has hooks for cartridges and loading from cassette.) The other 64KB is devoted to an extensive power-up and manufacturing self test, plus an expanded BIOS. The PC/AT has a type code of FCH at location FFFFEH. Table 4 shows the type codes for the current family members.

Three boards for the AT: the Serial/Parallel adapter (below) is optional on the basic model and standard on the enhanced; the 128KB memory expansion board (opposite page, top) is optional on both models; the Diskette/Fixed Disk adapter (opposite, bottom) comes standard with the AT.



Serial/Parallel adapter

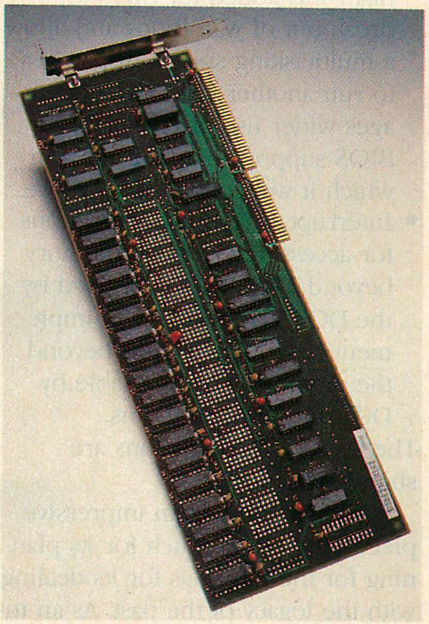
The AT BIOS is an impressive piece of work, as much for its planning for the future as for its dealing with the legacy of the past.

TABLE 5: *PC/AT BIOS Functions*

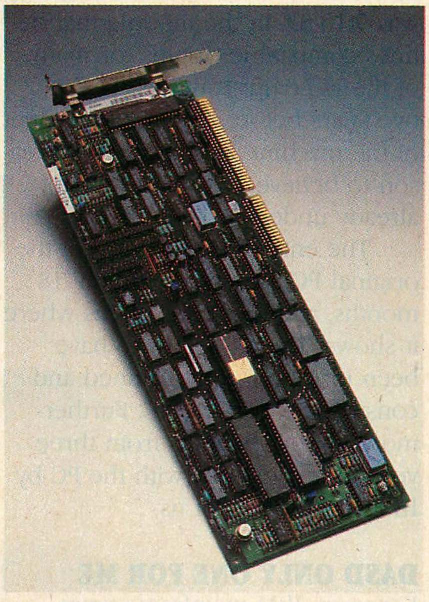
ROM BIOS functions are accessed through software interrupts 10 through 1F. Vectors 40 through 5F are also reserved for BIOS use. Functions in **boldface** are specific to certain PCs and return an error if requested in systems where they are not supported.

INTERRUPT NUMBER	MAJOR BIOS FUNCTION	SUBSIDIARY FUNCTION (AH)	
10	VIDEO	00	Set mode
		01	Set cursor type
		02	Set cursor position
		03	Read cursor position
		04	Read lightpen position
		05	Set active text page
		06	Scroll up
		07	Scroll down
		08	Read attr/char
		09	Write attr/char
		0A	Write char
		0B	Set color palette
		0C	Write dot
		0D	Read dot
		0E	Write TTY
		0F	Current video state
		10	**(PC*jr*) Set palette registers**
		11	Reserved
		12	Reserved
		13	**(AT) Write string**
11	EQUIPMENT CHECK	—	Return equipment flag
12	MEMORY CHECK	—	Return contig mem size
13	DISKETTE OR FIXED DISK	00	Reset disk system
		01	Read status
		02	Read sectors
		03	Write sectors
		04	Verify sectors
		05	Format track
	FIXED DISK	**06**	**(PC, XT) Format and set bad sector flags**
		07	**(PC, XT) Format drive**
		08	Get current drive parameters
		09	Initialize drive pair parameters
		0A	Read long (include 4 ECC bytes)
		0B	Write long (include 4 ECC bytes)
		0C	Seek
		0D	Alternate disk reset
		0E	**(PC, XT) Read sector buffer**
		0F	**(PC, XT) Write sector buffer**
		10	Test drive ready
		11	Recalibrate
		12	**(PC, XT) Controller RAM diagnostic**
		13	**(PC, XT) Drive diagnostic**
		14	Controller internal diagnostic
	FIXED OR DISKETTE	**15**	**(AT) Read DASD type**
	DISKETTE	**16**	**(AT) Read disk change line**
		17	**(AT) Set DASD type for format**
14	COMMUNICATIONS	00	Initialize comm port
		01	Send character
		02	Receive character
		03	Return comm port status
15	CASSETTE	**00**	**(PC, PC*jr*) Motor on**
		01	**(PC, PC*jr*) Motor off**
		02	**(PC, PC*jr*) Read blocks**
		03	**(PC, PC*jr*) Write blocks**

	MULTITASKING	**80**	**(AT) Device open**
		81	**(AT) Device close**
		82	**(AT) Program termination**
		83	**(AT) Event wait**
	JOYSTICK	**84**	**(AT) Read joystick**
		85	**(AT) System Request key pressed**
	MULTITASKING	**86**	**(AT) Wait**
	80286 SUPPORT	**87**	**(AT) Move block**
		88	**(AT) Get extended mem size**
		89	**(AT) Enter Virtual mode**
	MULTITASKING	**90**	**(AT) Device busy loop**
		91	**(AT) Set completion flag**
16	KEYBOARD	00	Read key
		01	Check key available
		02	Return shift status
		03	**(PCjr) Set typamatic rates**
		04	**(PCjr) Set/Clear keyboard click**
17	PRINTER	00	Print character
		01	Initialize printer
		02	Read printer status
18	RESIDENT BASIC	—	Entry to ROM BASIC
19	BOOTSTRAP	—	System bootstrap
1A	TIME OF DAY	00	Read clock
		01	Set clock
		02	**(AT) Read real-time clock**
		03	**(AT) Set real-time clock**
		04	**(AT) Read date**
		05	**(AT) Set date**
		06	**(AT) Set alarm**
		07	**(AT) Reset alarm**
		80	**(PCjr) Set sound multiplexer**
1B	Pointer to user keyboard break routine		
1C	Pointer to user timer tick routine		
1D	Pointer to video parameters		
1E	Pointer to diskette parameters		
1F	Pointer to character patterns (128-255)		
40	Reserved for Diskette I/O when fixed-disk BIOS installed		
41	Pointer to fixed-disk parameter table		
42-43	Reserved for BIOS		
44	**(PCjr) Character patterns (000-127)**		
45	Reserved for BIOS		
46	**(AT) Pointer to second fixed-disk parameter table**		
47	Reserved for BIOS		
48	**(PCjr) Cordless keyboard translation routine**		
49	**(PCjr) Non-keyboard scan code translation table**		
4A	**(AT) Pointer to user alarm routine**		
4B-5F	Reserved for BIOS		
80-8F	**(PCjr) Used during POST and built-in diagnostics**		



128KB memory expansion board



Diskette/Fixed Disk adapter

BIOS

The PC/AT BIOS and POST is four times bigger than the 8KB BIOS and POST of the XT, and it does more. BIOS exists to provide I/O support and a uniform interface across the PC family. Most of the additional space is taken up by added functions:

- Parity errors display a message telling which bank of memory failed, not just 1 or 2 for system or I/O channel.
- Fixed-disk BIOS is included on the system board, rather than on the controller card
- Diskette BIOS is considerably more complicated due to the various combinations of media and drive types that must be handled
- Code was added to manage the new clock/calendar and configuration memory, including an alarm feature that will call a user routine through INT 4AH when the alarm "rings."
- Functions for multitasking support were added to INT 15H

(formerly Cassette I/O). A mechanism was added for BIOS to break out of wait loops and allow a multitasking system dispatcher to run another task. This encourages wider use of the standard BIOS support in applications in which it was not feasible before.

- Interrupt 15H also has functions for accessing extended memory beyond 1MB. These are used by the DOS VDISK driver to implement large virtual disks beyond the memory directly usable by DOS and user programs.

The PC/AT BIOS functions are shown in table 5.

The AT BIOS is an impressive piece of work, as much for its planning for the future as for its dealing with the legacy of the past. As an indication of the effort, the earliest date I could find in the BIOS listing was 9/16/82, in the module that defines compatible origins for many of the interrupt routines. That is two years before the announcement of the machine, and there is no reason to believe that work was not already underway even then.

The entire development of the original PC took place in only 18 months, and there are places where it shows. The AT seems to have been more carefully planned and constructed than the PC. Furthermore, the AT benefits from three years of experience with the PC by IBM and the rest of us.

TABLE 6: *Built-in Drive Types Supported by XT Fixed-disk BIOS*

DRIVE TYPE	0	1	2	3
CYLINDERS	306	375	306	306
HEADS	2	8	6	4
WRITE PRECOMP	no	no	256	no
CAPACITY (MB)	5.3	26.1	15.9	10.6

TABLE 7: *Built-in Drive Types Supported by AT Fixed-disk BIOS*

DRIVE TYPE	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CYLINDERS	306	615	615	940	940	615	462	733	900	820	855	855	306	733
HEADS	4	4	6	8	6	4	8	5	15	3	5	7	8	7
WRITE PRE-COMP	128	300	300	512	512	no	256	no	no	no	no	no	128	no
LANDING ZONE	305	615	615	940	940	615	511	733	901	820	855	855	319	733
CAPACITY (MB)	10.6	21.4	32.1	65.4	49.0	21.4	32.1	31.9	117.5	21.4	37.2	52.0	21.3	44.6

DASD ONLY ONE FOR ME

For years IBM mainframe types have spoken of DASD (pronounced DAZ-dee), which is an ancient Druid acronym for Direct Access Storage Device—DASD disk to you and me. Now, just when I was getting used to calling it a *fixed* instead of a *hard* disk, IBM starts calling it DASD. This is probably a strategy to suck in the remaining DP VPs and MIS directors who would not go near a PC that has a *floppy*. But if it has a DASD, why then it must be a *real* computer.

Both models of the AT come standard with one High Capacity 1.2MB Diskette Drive and a combination Fixed Disk and Diskette Drive Adapter, a single card that controls both diskettes and fixed disks. The diskette portion is compatible with the PC diskette adapter, but it has some additional registers to control data rate selection, the diskette change signal (new on the AT half-height drives), and the fixed-disk interface. The fixed-disk part is not hardware-compatible with the XT disk controller. BIOS, of course, masks the hardware differences for those programs that are smart enough to use DOS or BIOS to get to the DASD.

The adapter has a 16-bit data path to the on-board 512-byte sector buffer, and it therefore must occupy one of the six 16-bit adapter slots. The buffer can be accessed at the rate of 2MB per second using the 80286 string I/O instructions. BIOS uses the string I/O, rather than DMA, to transfer data between the adapter and system memory. DOS uses an interleave factor of three for the AT fixed disk; the XT uses a factoring of 6, which makes long sequential transfers take roughly twice as long on the XT as they do on the AT. The AT adapter also supports multiple sector transfers across track and cylinder boundaries, which, if DOS takes advantage of the feature, should provide a significant performance improvement over the XT.

The DASD adapter supports two diskette drives and two fixed-disk drives, but the system unit has room for only three DASD devices: two 20MB fixed disks and one diskette drive, or one 20MB drive and two diskettes.

The fixed-disk BIOS is part of the AT system board ROMs and is not on the adapter card as in the PC/XT. The BIOS has a built-in table of parameters for 14 different fixed-disk drive types, ranging from 10.6MB to 117.5MB. The PC/XT BIOS supported only four types, ranging from 5.3MB to 26.1MB (see tables 6 and 7). While there is certainly no guarantee that any of these other drives will actually be offered by IBM, it is interesting to see the groundwork there.

A jumper on the adapter selects one of two I/O address ranges for

the card, apparently to allow a second adapter in the same system. BIOS uses only one set of addresses and thus can support only a single adapter. Future operating systems, however, may be able to take advantage of multiple adapters and expansion boxes in order to support large amounts of secondary storage. Four type-9 fixed drives (117.5MB each) would provide more than 470MB of storage!

A final speculation on fixed disks for the AT: the *Technical Reference Manual* describes the 20MB disk as having six read/write heads. A little multiplication reveals that is 32MB, not 20. A 20MB drive should only have four heads. I checked the logic diagram for the drive, expecting to see just four heads and the associated drivers and amplifiers. Guess what? The diagram also showed six heads. Unfortunately, when I told the set-up program that the disk was a type-3 drive, the POST failed after about four minutes, with a disk error. Bottom line: it probably is a 20MB drive, but I'll bet a 32MB unit will be available *very* soon. Meanwhile, if anyone discovers a secret jumper that enables the extra two heads, please let us know.

DISK BUD'S FOR YOU

Besides the 1.2MB diskette drive, IBM also offers a 360KB diskette drive for compatibility with the PC family (see table 8). The high-capacity drives spin faster, record at higher bit densities, and have twice as many cylinders as the 360KB drives. In addition, they use a special high-coercivity, cobalt-modified iron oxide media rather than plain iron oxide. The new media require higher write current and cannot be used in 360KB drives.

The high-capacity drive will accept either kind of media and can read or write any of the diskette formats: high-capacity, single-sided 160/180KB, and double-sided 320/360KB. However, due to the narrower heads of the 96-tpi drives, once the high-capacity drive is used to write on standard media, use of the diskette in regular drives is said to be unreliable.

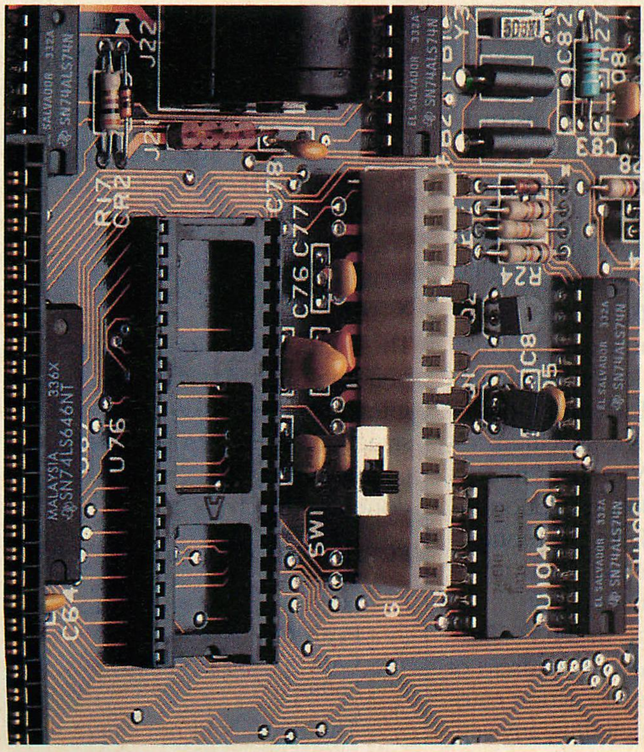
The only way to write diskettes on an AT that can be reliably read on other PCs with standard drives is with the optional 360KB diskette drive. If you only have a high capacity drive, you can read anybody's diskettes, but you will have to resort to communications to send data or programs to your technologically disadvantaged friends.

PROCESSOR COMPATIBILITY

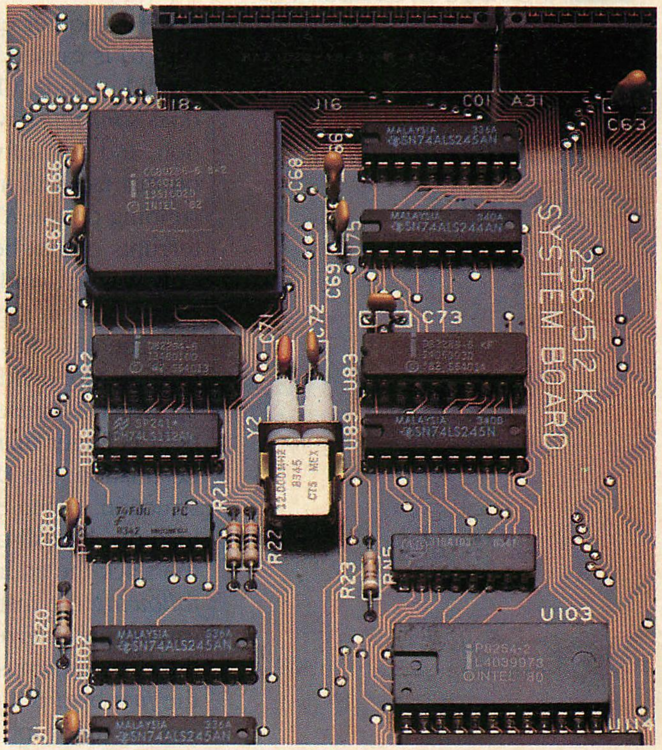
The 80286 processor executes the same instructions as the 8086/8088 processors, plus additional ones intended to support efficient, high-level language implementations and to control the additional functions of Protected mode.

Although the 8088 and 80286 are very compatible, they do have

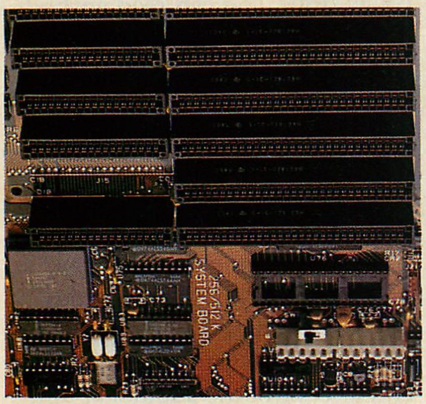
IBM has eliminated the DIP switches of the PC in favor of software settings in CMOS. One important switch is left, however; it is the one that tells the system which type of display adapter is attached as the default display device.



The square Intel 80286 chip is shown in the upper left corner. A 12MHz crystal is used to generate the 6MHz clock rate used by the processor. Notice that the crystal is plugged into a socket.



Six of the eight AT slots use the full 16-bit bus. Two of the slots, numbers 1 (not shown) and 7, have only the PC-compatible 8-bit connector.



The 80286 processor recognizes four kinds of interrupts: two that are internally generated and two from external sources.

TABLE 8: *PC/AT Diskette Drives*

	HIGH CAPACITY	STANDARD
CYLINDERS	80	40
HEADS	2	2
SECTORS/TRACK	15	8/9
FORMATTED CAPACITY	1.2MB	320/360KB
TRACKS PER INCH	96	48
DATA RATE (HIGH CAPACITY)	500Kbps	n/a
DATA RATE (320/360 KB)	300Kbps	250Kbps
ROTATIONAL SPEED	360rpm	300rpm
AVERAGE ACCESS TIME	94ms	91ms

differences that will affect some programs. Obviously, programmed timing loops that expect a 4.77 MHz 8088 will execute faster. A more interesting—and subtle—set of differences arises because of the provisions for memory protection and virtual addressing.

In the 8088, segments are always 64KB long, spanning offsets 0000H through FFFFH. Instructions that access a word operand at offset FFFFH get the first byte from FFFFH and the second from 0000H. In the 80286, segments no longer wrap this way. Instead, the processor will cause an exception interrupt (interrupt 13) for word operands at offset FFFFH. Another exception (interrupt 6) is caused by executing an invalid opcode. (The 8088 always does *something* with every instruction, and any software that depends on that fact will have a tough time running on the AT.) Exception interrupts cannot be disabled; the only way to avoid them is not to cause them in the first place.

The 8088 has an exception interrupt, too: divide error (interrupt 0), which is caused when the quotient is larger than the specified destination of a DIV or IDIV instruction. In the 8088, exception interrupts, like all others, push onto the stack the address of the byte *following* the instruction that caused the interrupt. In the 80286, the processor pushes the address of the *first* byte of the instruction causing the interrupt, including any segment override prefixes that may have affected the instruction. This allows the exception interrupt handler to evaluate the instruction and possibly correct the situation and try again. This is especially valuable in Protected mode, where an operating system may be able to correct an addressing error by assigning more memory to a task, then restarting it at the same instruction that caused the exception.

There are a few more differences between the processors that may catch the unwary assembly language programmer. PUSH SP pushes the current SP in the 80286, and the new SP in the 8088. It is hard to imagine a use for PUSH SP in either case, but if you care about the value, move SP to another register and then push that one. The following code has the same effect as the 8088 PUSH SP instruction on either processor:

```
PUSH        BP
MOV    BP,  SP
XCHG   BP,  [BP]
```

The POPF instruction may allow pending interrupts to occur even if interrupts are masked by the CLI instruction. There is a work-around (published by IBM), which is best done as a macro:

```
POPFF   Macro     ; Can't call it POPF
    JMP $+3       ; Skip IRET
    IRET          ; Pops IP, CS, flags
    PUSH CS       ; Push CS
    CALL $-2      ; Push IP
    Endm          ; Continue here
```

The 80286 will not single-step

through an interrupt handler caused by an external interrupt that occurs while single-stepping was already in effect. This is good news for users other than the ones using the debugger to single-step through a program. Single-stepping is still possible through an interrupt routine invoked by an INT instruction.

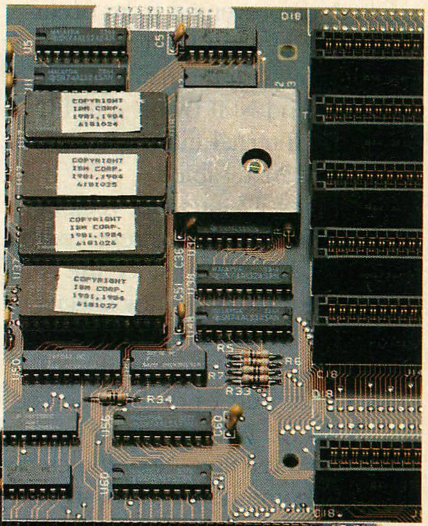
Shift and rotate counts are masked to 5 bits (0 to 31). Thus, a shift count of 36 behaves like a shift count of 4. This was done to reduce the maximum shift instruction time from 264 clocks on the 8088 to 39 clocks, thereby improving interrupt response times.

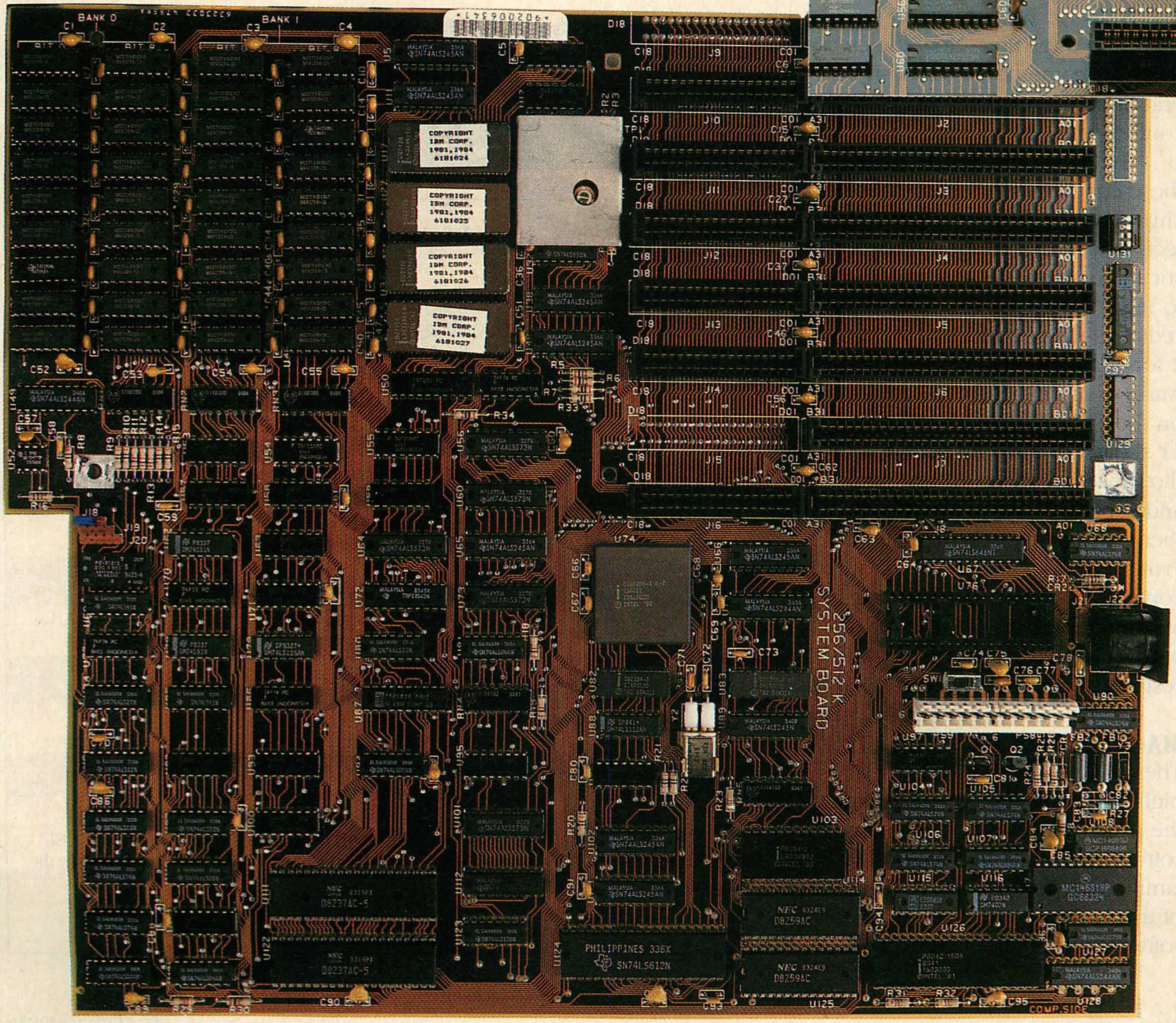
The 80286 is fast enough that successive I/O instructions to the same device may execute faster than the device can respond. Inserting a JMP $+2 instruction between I/O instructions to the same port should allow enough recovery time. Other instructions generally won't do, because of the pipelined instruction queue in the 80286. Jumps purge the queue and ensure that the next instruction will have to be fetched from memory before it can be executed.

EXCUSE THE INTERRUPTION

The 80286 processor recognizes four kinds of interrupts, two internally generated and two from external sources. Internal interrupts are

A separate 14.318MHz crystal generates PC-compatible clock rates. The crystal is hidden under a metal shield because of its potential to generate radio frequency interference. Also shown are the ROMs containing BASIC and BIOS. The machine tested by PC Tech Journal *contained four ROMs; some machines may have only two.*





The AT system board has approximately the same functionality as the earlier PC and XT boards. The major increase in density is memory: the AT board can contain up to 512KB of RAM. Additional circuitry provides twice as many DMA channels and a doubling of the bus width to 16 bits.

generated by the INT instructions (software interrupts), and by certain processor-detected error conditions (exceptions). The external interrupts are NMI (non-maskable interrupt) and INTR (hardware interrupt request from devices attached to one of the 8259A interrupt controllers). External interrupts can be masked, or prevented from occurring: INTR by the CLI instruction, or individually with the 8259A mask registers; and NMI by bit 7 in I/O port 70H. Internal interrupts cannot be masked or disabled.

The first 32 interrupt vectors (00H through 1FH) are reserved by Intel (and have been since the earliest days of the 8086) for special processor functions. IBM chose to ignore Intel's warnings in the PC design and used 24 of the reserved interrupts for BIOS functions and hardware interrupts. Now the chickens have come home to roost: several of the new exception interrupts conflict with IBM's usage.

The AT design avoids some of these conflicts with a custom logic chip on the system board that detects and redirects numeric processor interrupts to IRQ13, which goes to interrupt vector 75H. (BIOS then redirects those interrupts to vector 2 for compatibility with PC software, which expects 8087 interrupts on the NMI line.) Tables 9, 10, and 11 show the interrupt vector conflicts that can occur in Real mode and suggests ways to avoid some of them. Operating systems written for Protected mode can avoid all of the conflicts by replacing BIOS and assigning interrupt vectors for hardware IRQs to vectors that are reserved for user programs.

TABLE 9: *80286 Dedicated and Reserved Interrupt Vectors*

INTERRUPT NUMBER (HEX)	MEANING
00	Divide error
01	Single-step interrupt
02	Nonmaskable interrupt
03	Breakpoint
04	INTO detected overflow
(*) 05	BOUND range exceeded
(*) 06	Invalid opcode
(*) 07	Processor extension unavailable
(*) 08	Double exception detected
(*) 09	Processor extension seg overrun
(P) 0A	Invalid task state segment
(P) 0B	Segment not present
(P) 0C	Stack segment not present or overrun
(*) 0D	General protection exception (segment overrun)
0E	Intel reserved
0F	Intel reserved
(*) 10	Processor extension error (e.g., 80287)
11-1F	Intel reserved
20-FF	User defined

(*) 80286 exception interrupt that may occur in any mode
(P) Exception interrupt possible only in Protected Virtual Address Mode

TABLE 10: *PC/AT Hardware Interrupts*

INTERRUPT NUMBER (HEX)	MEANING
02	NMI parity or I/O check
08	IRQ0 8254 timer 0
09	IRQ1 8042 keyboard controller (OBF)
0A	IRQ2 slave interrupt controller (never uses vector) vector used for redirection of IRQ9 (which occupies same place in IOC as IRQ2 did in PC, which is now used by LAN)
0B	IRQ3 serial communications 2, LAN adapter 2
0C	IRQ4 serial communications 1
0D	IRQ5 parallel printer 2
0E	IRQ6 diskette controller
0F	IRQ7 parallel printer 1
70	IRQ8 real-time clock
71	IRQ9 LAN adapter 1 (vector redirected to INT OAH—IRQ2)
72	IRQ10 reserved
73	IRQ11 reserved
74	IRQ12 reserved
75	IRQ13 80287 error (vector redirected to NMI vector)
76	IRQ14 fixed-disk controller
77	IRQ15 reserved

Note: NMI, IRQ0, IRQ1, IRQ2, IRQ8, and IRQ13 are generated locally on system board. IRQ3 through IRQ7, IRQ9 through IRQ12, and IRQ14 through IRQ15 are available in the I/O channel.

MACHINE FOR MODERN TIMES

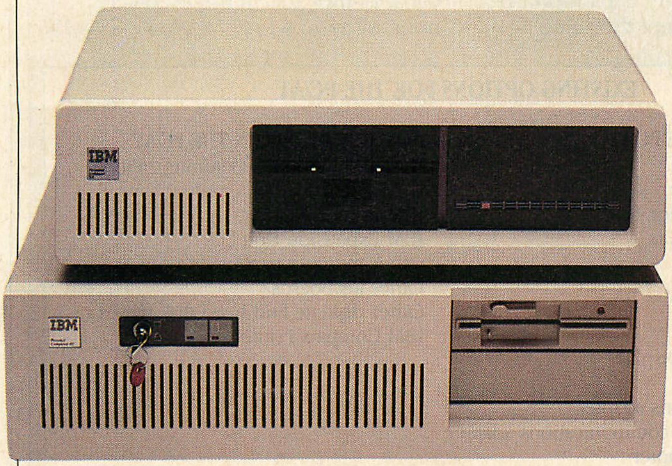
The published BIOS, DOS, and high-level language interfaces are the primary means for maintaining software compatibility within the PC family. The power and performance of the AT make it less tempting for software writers to circumvent the

TABLE 11: *Conflicts Between 80286 Exceptions and AT BIOS*

INTERRUPT	80286 EXCEPTION	PC/AT USAGE
05	BOUND exception	BIOS print screen function
	(Could write handler to inspect instruction causing interrupt: if INT 5 then call original handler, else deal with exception. Cannot do it perfectly, however, since one case points to offending instruction, and the other points after. Only sure method is to avoid the BOUND instruction.)	
06	Undefined opcode	Not used
	(No conflict)	
07	8087 not available	Not used
	(No conflict)	
08	Double exception	IRQ0 timer 0
	(Can only occur in Real mode if LIDT instruction changes interrupt table to be too small. Default is 3FFH, which allows for all interrupts).	
09	80287 segment overrun	IRQ1 keyboard
	(May not occur, if system board logic directs *all* 80287 errors to IRQ13.)	
0D	Segment overrun	IRQ5 alternate printer
	(Only reasonable strategies are careful coding and avoiding IRQ5. It would be possible, but impractical, to emulate instruction pointed to by stack to see if it will cause the exception.)	
10	80287 error	BIOS video I/O function
	(No conflict, since system board logic directs 80287 error interrupts to IRQ13.)	

official compatible ways of doing things and should give incentive to vendors to build "well-behaved" software that plays by the rules. IBM's announced compatibility policy is a reasonable one: it will try to take advantage of technology to improve function and performance, and not knowingly change existing interfaces to hardware or software without the justification of some benefit to the users.

Maintaining compatibility at and above the BIOS level allows the hardware to change, sometimes drastically, without invalidating the heavy investment in software. This open-system strategy benefits everyone: users, independent hardware and software developers, and most certainly IBM. The PC-AT will have a long and productive life in these modern times.



The XT is just slightly smaller in each dimension than the AT. The AT's greater height accommodates taller adapter boards.

A comparison of the PC and AT keyboards reveals that there is little difference between the two. But IBM listened: the backslash key has moved, important shift keys are bigger, and indicator lights have been provided to display shift, numlock, and scroll states. One new key has been added—Sys Req—and one poor choice made: the ever-popular Esc key was relocated from its almost standard location to the other side of the keyboard.

Adapter Compatibility

The PC/AT designers went to great lengths to achieve a high degree of compatibility between the AT and the other members of the PC family in hardware as well as in software. Custom LSI circuits are used in the I/O channel interface section of the system board in order to allow existing eight-bit devices (both I/O and memory) to function in the expansion slots. Sixteen-bit devices are supported in six of the eight expansion slots with an additional 36-pin connector that contains the necessary additional control, address, and data signals.

The *Personal Computer AT Technical Reference Manual* says the AT does *not* support any keyboards, memory adapters, or serial or printer adapters other than the ones that are made especially for the AT. Technically, this seems to be false (refer to the accompanying table).

Starting with the fact that the AT *does* support the same display adapters as the other IBM PCs, it follows that both I/O and memory transfers of eight bits must be supported in the expansion channel. So, if the AT supports reading and writing the 6845 control registers and display buffer of a video card, why should the I/O registers of a UART on a communications adapter or the memory on an eight-bit memory card be any different? Well, the answer is they shouldn't.

I tried several supposedly incompatible devices with the AT, and they all appeared to work without any problems. Of course, it is possible that there may have been subtle problems occurring that I missed, but I think it is more likely that this is IBM's way of averting a lot of complaints about less-than-expected performance or odd behavior due to erroneous installation and set up. If you try something and it works and you're happy, that's fine. If it doesn't—well, they never promised you a rose garden.

The old PC keyboard is supported by the 8042, but it requires special programming, and it may not be possible to pass POST without an AT keyboard. I did get a standard PC keyboard to work on the AT by sending the appropriate command to the 8042 keyboard controller, but I did not do exhaustive tests. I never figured out how to revive the AT keyboard without resetting the system.

The PC serial adapter works in the AT, as should the PC printer adapter. (Check to be sure that the I/O addresses and functions are the same.) It may get too confusing, with monochrome printer, PC printer, and AT serial/printer cards. Maybe there is no convenient way to select suitable addresses. Again, POST and BIOS init may not find nonstandard adapters, but you could always place their addresses in the lists at 40:0H.

Eight-bit memory cards seem to work, too (I tried an old IBM 64KB expansion card). The set-up program didn't offer memory size choices other than those that were possible with the AT 16-bit memory expansion options, but it did accept the value 576KB (512KB on the system board plus the 64KB card in the I/O channel) when we supplied it. As might be expected, the eight-bit memory is significantly slower. The time taken by the POST to check the last 64KB was perceptibly longer than for the 16-bit wide system memory.

In the other direction, it seems that the AT Serial/Parallel Adapter should work in a standard PC, but again the compatibility chart says no. I tried it, however, and it seemed to work. The serial port has a 9-pin, D-shell connector instead of the standard 25-pin connector, but an adapter cable is available.

In summary, IBM's protestations of non-support seem a bit conservative, but you will not go wrong behaving as though they were true. Most AT users probably will not be trying to use a lot of salvaged parts from other PCs anyway. Multifunction boards with memory, clock/calendars, parallel, and serial ports just do not make as much sense in the AT, a system where all those features are standard, as they did in the PC where none of them were. —TH

EXISTING OPTIONS FOR THE PC/AT

SUPPORTED ON THE PC/AT	NOT SUPPORTED ON THE PC/AT
Display stand	IBM Asynchronous Communications Adapter
PC Network Adapter	IBM Printer Adapter
PC Network Translator Unit	IBM Expansion Unit
PC Network Cable Kits	Other memory expansion options
IBM Color Printer	Other keyboards
IBM Graphics Printer	Other diskette and fixed-disk drives
Printer cable	IBM Compact Printer
Printer stand	
IBM Monochrome Display	
IBM Color Display	
SDLC communications adapter	
Binary synchronous communications adapter	
Cluster Network Adapter	
Monochrome display and printer adapter	
Color/graphics monitor adapter	
Communications cable	
Game adapter	

Setting The AT's Clock

A plug for a small IBM hole

TECH NOTEBOOK 28

WILL FASTIE

When IBM provided the AT with a real-time clock, it left a little work undone: the DOS DATE and TIME commands have no effect on the CMOS real-time clock. The SETUP program provided on the diagnostic diskette in the *Guide to Operations* can be used to set the real-time clock, but it requires rebooting the system. The batch file SETRTC.BAT in listing 1 invokes the DOS DATE and TIME functions, then executes TAD in listing 2, which plugs the new DOS values into the real-time clock by using the BIOS interrupt 1A.

LISTING 1: SETRTC.BAT

```
echo off
rem Usage is SETCLOCK [date [time]]
date %1
time %2
tad
echo on
```

LISTING 2: TAD.ASM

```
  page          55,132
  title         TAD:  Time and Date Program for PC/AT
; Author:       Will Fastie               on 84/10/01 10:05
; Environment:  IBM PC/AT, DOS 3.00 or higher
; DOS Syntax:   TAD
;
; This program provides a DOS command to set the DOS date and time
; into the BIOS real-time-clock; the BIOS routine also sets CMOS.
; On other PC family members and in DOS 2.00+, the program runs but
; has no effect.
;-----------------------------------------------------------
; Declarations:  equates, macros, etc.
;
TERMINATE       equ     4CH     ;terminate program execution
GETDATE         equ     2AH     ;read DOS' date
GETTIME         equ     2CH     ;read DOS' time
RTC             equ     1AH     ;access real-time clock
  WTIME         equ     03H     ;  write the clock and CMOS
  WDATE         equ     05H     ;  write the date and CMOS
;------------
DOS     macro   fcn_code
        mov     ah,fcn_code
        int     21H
        endm
;------------
BIOS    macro   int_no, fcn_code
        mov     ah,fcn_code
        int     int_no
        endm
;------------
B2BCD   macro   register        ;convert reg to BCD in-place
        mov     al,register     ;get numerand
        call    B2_BCD          ;call routine
        mov     register,al     ;put the result back
        endm
;-----------------------------------------------------------
; Setup so EXE2BIN can convert program to .COM format
CSEG    segment para public 'CODE'
        assume  cs:CSEG, ds:CSEG
;
        org     100H
START:  jmp     GO              ;jump around the data area
;-----------------------------------------------------------
BY10    db      10              ;for when we divide by 10
BY100   db      100             ;for when we divide by 100
;-----------------------------------------------------------
MAIN    proc    far             ;cleanliness
GO:     DOS     GETDATE         ;get DOS' date
        mov     ax,cx           ;convert the year into binary
        div     by100           ;...halves.
        xchg    ah,al           ;then, put
        mov     cx,ax           ;...century in ch, year in cl
        B2BCD   ch              ;now convert each byte to BCD
        B2BCD   cl
        B2BCD   dh
        B2BCD   dl
        BIOS    RTC,WDATE       ;and write the date via BIOS
        DOS     GETTIME         ;get DOS' time
        B2BCD   ch              ;convert each byte to BCD
        B2BCD   cl
        B2BCD   dh
        mov     dl,0
        BIOS    RTC,WTIME       ;write the time via BIOS
EXIT:   xor     al,al           ;=0; returns OK for errorlevel
        DOS     TERMINATE       ;goodbye
MAIN    endp
;-----------------------------------------------------------
B2_BCD  proc    near            ;al has binary value
        cbw                     ;make it a full word in ax
        div     BY10            ;divide by 10
        shl     al,1            ;put the quotient in the high nibble
        shl     al,1
        shl     al,1
        shl     al,1
        or      al,ah           ;put the two nibbles together in al
        ret
B2_BCD  endp
;-----------------------------------------------------------
CSEG    ends
        end     START
```

Configurations and Pricing in the IBM Family

How the Model 5170 stacks up against the competition, including IBM's own

WILL FASTIE

The very existence of the PC/AT leads to inevitable questions. Does it replace the PC/XT? Where does it fit in the IBM product line? Which machines from other vendors compete with it?

And if one is to be purchased, what exactly needs to be specified? What additional equipment, if any, should be purchased?

Let's start with questions of configuration and then, once the pricing is understood, move on to a simple analysis of the AT's position in today's market.

IBM offers two configurations of the PC/AT system unit. They are simple to understand: the less expensive entry (my adjective) model (IBM part number 5170068) is a diskette-based unit with 256KB of RAM; the so-called "enhanced" model (5170099) includes an IBM fixed disk and 512KB of RAM. A quick look at pricing, however, reveals an interesting fact: the enhanced system is $440 less than an entry model upgraded to the same capacity (see table 1). This is one of the few instances in which IBM has offered an incentive (and a considerable one) to a customer for avoiding a lower-level version of the product. It may seem as if IBM wished to encourage sales of the enhanced model only, but, as we shall see, the entry model may prove to be a rational choice for the long term.

IBM has two good reasons for offering such an incentive. First, when compared with the cost of packaging, stocking, distributing, and selling a 256KB upgrade kit, a significant manufacturing savings is realized if the AT system board is fully populated with memory at the time it is built. Second, IBM may

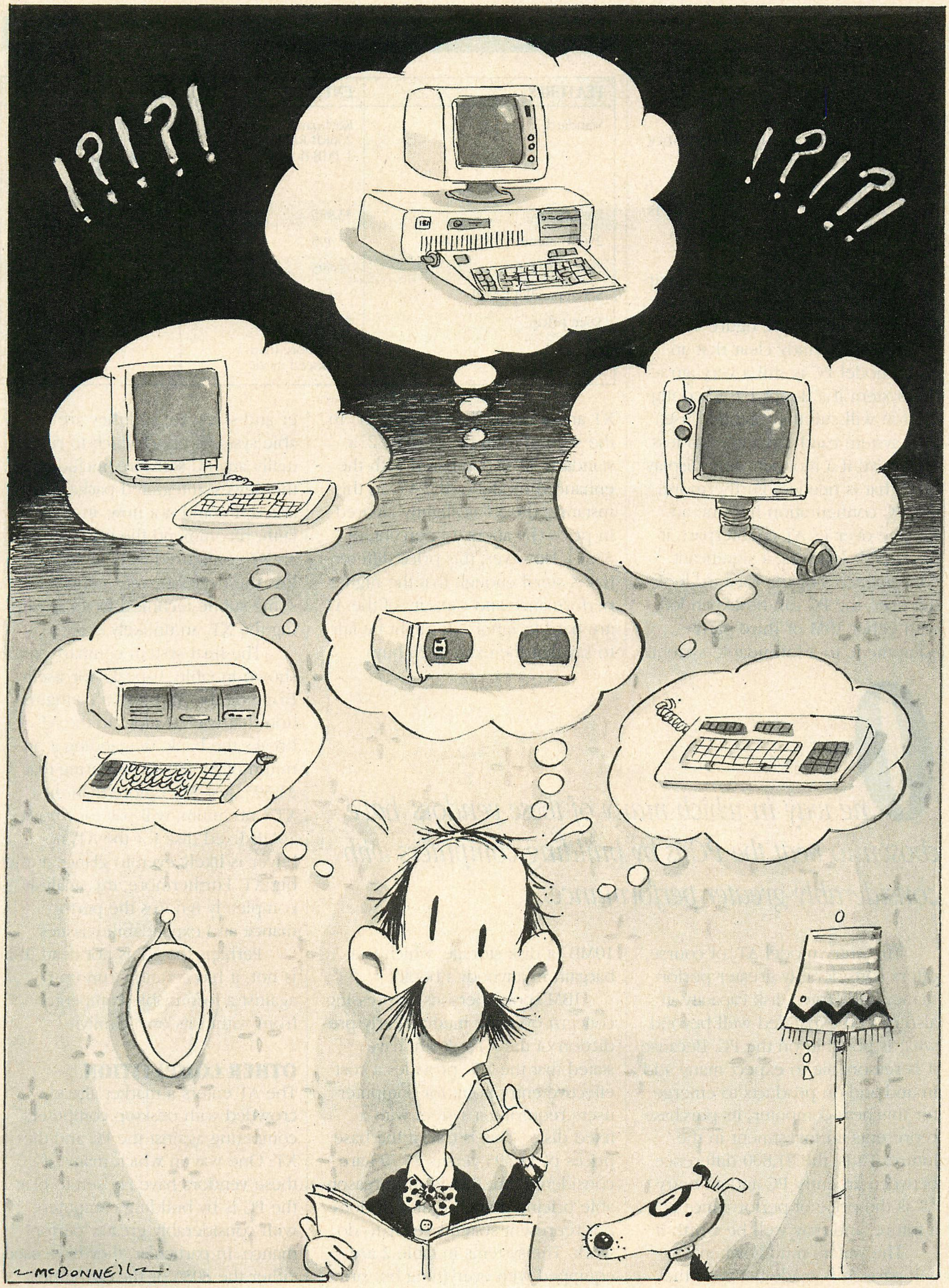


ILLUSTRATION • PATRICK McDONNELL

reap long-term savings in maintenance by virtue of the inherent reliability of a board whose construction was under IBM's control, the avoidance of third-party memory suppliers whose quality IBM cannot control, and the elimination of user-installed electronic components. In fact, the savings of $440 is very close to IBM's price of $495 for the 256KB upgrade.

A more revealing price comparison can be seen in table 2 and its corresponding graph, figure 1.

It is abundantly clear that an entry model PC is still a very attractive system if a floppy-based configuration will suit the intended use. This system can be made even less expensive if a monochrome display is all that is needed. Furthermore, this PC configuration has one advantage over its AT counterpart: it has *two* disk drives, a significant convenience. For the forward-looking user, the PC can be expanded, with either IBM or third-party equipment, to a formidable system.

TABLE 1: *Price Comparison—Base and Enhanced System Units*

FEATURES	ENTRY AT	ENHANCED AT
Standard	Keyboard 256KB RAM 1.2MB floppy	Keyboard 512KB RAM 1.2MB floppy 20MB fixed disk Serial/parallel board
Base price	$3,995	$5,795
256KB memory expansion	495	
20MB fixed disk	1,595	
Serial/parallel board	150	
Total price	$6,235 ↑ $440 more than enhanced mode	$5,795

One way in which many of these vendors have chosen to beat the PC is by building computers with considerably greater performance.

The entry model AT, of course, offers considerably greater performance and larger disk capacity. It also can be expanded well beyond what is possible on the PC. Because it is reasonable to expect many add-in and add-on products to emerge for this new computer, its purchase represents an investment in the future. Thus, the $1,800 difference between an entry PC and an entry AT is the price of performance and a future, and may well be worth it.

The waters muddy when a comparison is made between the XT and a similarly equipped AT. In the second example of table 2, a standard XT is compared with the enhanced model of the AT. In this instance, the XT is slightly favored in price (by about 14 percent, or $825). However, this price differential is small enough that the higher performance and capacity of the AT are hard to ignore. It might be fair to say that the extra $825 buys 10MB of disk storage, which is a bargain in anybody's book.

IBM spokespersons, expressing concern over the media's early prediction of the XT's death, have stated that the XT "provides a cost-effective entry point for computer users requiring a system with a fixed disk." This is true if the base prices of $4,395 versus $5,795 are considered, but that is an unreasonable pricing point, because it does not represent systems ready to do work. The systems in table 2 are equipped with everything but printer and software, and they are suitable systems upon which to run virtually any PC software, including the newest integrated packages. If asked, I could not now, in good faith, recommend the purchase of an XT configured as in table 2 unless the decision were mitigated by some subtle technical factor regarding the XT, an unlikely event.

The final system comparison shown in table 2 speaks for itself. Bringing the XT up to a configuration that is equivalent to the AT breaks the bank, demanding a premium of $1,480. Considering that $1,595, just $115 more than the XT's premium, will pay for *another* 20MB fixed disk for the AT, no buyer is likely even to glance at the big XT. Furthermore, this analysis completely ignores the performance and expandability issues.

Perhaps the XT is not dead. If it is not, it has certainly run up against a formidable competitor from within its own family.

OTHER COMPETITION

The AT enters a market already crowded with desktop computers competing against the PC and the XT. One way in which many of these vendors have chosen to beat the PC is by building computers with considerably greater performance. In particular, they have used either the 8086 or the 80186 pro-

TABLE 2: *Price Comparison—Various IBM Systems*

SYSTEM TYPE AND FEATURES	SYSTEMS COMPARED	
256KB, Floppy-based	**IBM PC**	**IBM PC/AT**
PC system unit, two 360KB drives	$2,240	
AT system unit, 1 1.2MB drive		$3,995
Serial adapter	100	
Parallel adapter	75	
Serial/parallel adapter		150
Serial adapter cable		65
Graphics subsystem	924	924
Total	$3,339	$5,134
512KB, 10MB Fixed Disk	**IBM PC/XT**	**IBM PC/AT**
XT system unit, 1 360KB floppy, 1 10MB fixed disk, Serial adapter	$4,395	
AT system unit, 1 1.2MB floppy, 1 20MB fixed disk, Serial/parallel adapter		$5,795
256KB RAM upgrade	565	
Serial adapter cable		65
Parallel adapter	75	
Graphics subsystem	924	924
Total	$5,959	$6,784
640KB, 20MB Fixed Disk	**IBM PC/XT**	**IBM PC/AT**
XT system unit, 1 360KB floppy, 1 10MB fixed disk, Serial adapter	$4,395	
AT system unit, 1 1.2MB floppy, 1 20MB fixed disk, Serial/parallel adapter		$5,795
XT expansion chassis, 1 10MB fixed disk	2,290	
256KB RAM upgrade	565	
128KB RAM upgrade	365	350
Serial adapter cable		65
Parallel adapter	75	
Graphics subsystem	924	924
Total	$8,614	$7,134

Notes:
Systems are configured with the least expensive IBM graphics display system available: Color/Graphics Adapter ($244) and IBM Color Display ($680).

Systems are configured to be as equivalent and ready-to-use as possible, except that the smaller XT with 10MB of fixed disk is compared with a 20MB AT.

Systems do not include printers, but are configured to be ready to connect one.

cessor, and have widened their bus to 16 bits. Some also offer fixed-disk options of higher capacity than the XT, along with back-up facilities.

I have chosen five systems from this field to compare against the AT: the Tandy TRS-80 Model 2000, two models of the Wang PC, the Compaq Deskpro Model 3, and lastly, the MAD-1. Table 3 lists the features of each system, including the AT. In each case, the machines claim performance levels of two to three times that of a standard PC.

Table 4 configures each of the five systems to the same approximate level (most have only 10MB of hard disk) and prices them. Figure 2 shows the price difference between the AT and the competing systems. Clearly, the AT is more expensive than the other machines in the field, each of which delivers similar performance. The exception is the Wang PC with the 30MB fixed-disk option, which commands a large but reasonable premium for its extra 10MB of mass storage.

This is fierce competition. For many applications and environments, the other systems offer cost-effective and powerful solutions. What advantage the IBM PC/AT has over these systems, especially if it is not price? The answer is complex and may have more to do with IBM's extraordinarily aggressive posture, demonstrated by the introduction of almost 150 IBM-label products for the PC family in the last six months. Not the least of these are the two new graphics display subsystems and the extensive graphics software library built around the GKS standard. There is enhanced programming language support, with even more promised. And, perhaps most significantly, there is the 80286 processor and all that it implies for new operating environments, high power, and multiuser applications.

Table 5 has all the prices for the AT, network, and graphic display devices and software.

FIGURE 1: *AT vs. XT Pricing Crossover*

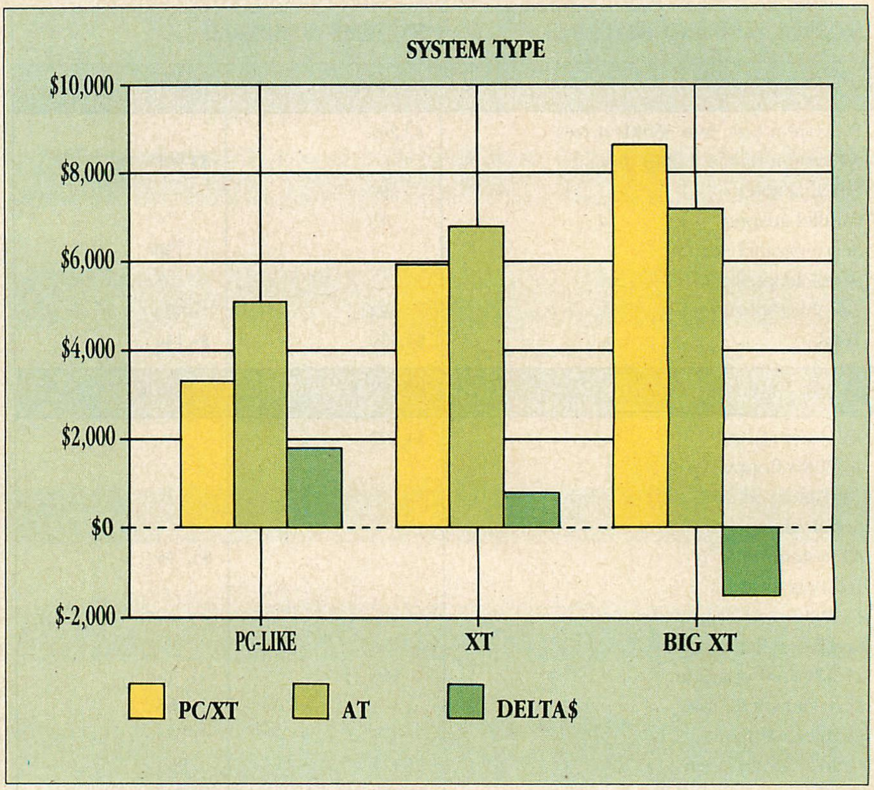
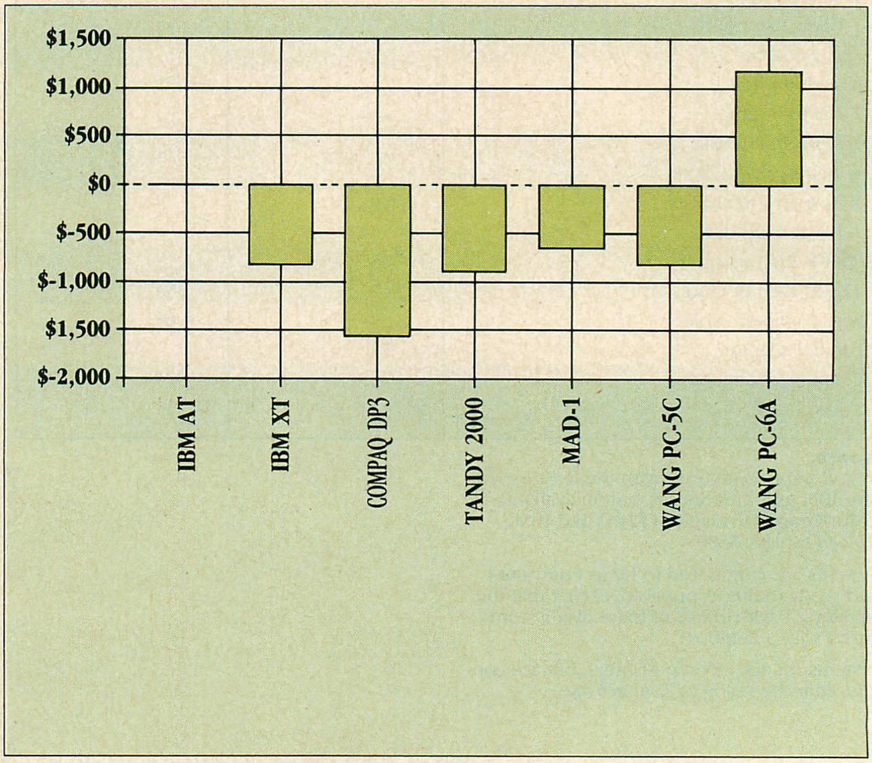


FIGURE 2: *Price Difference between AT and Other Machines*



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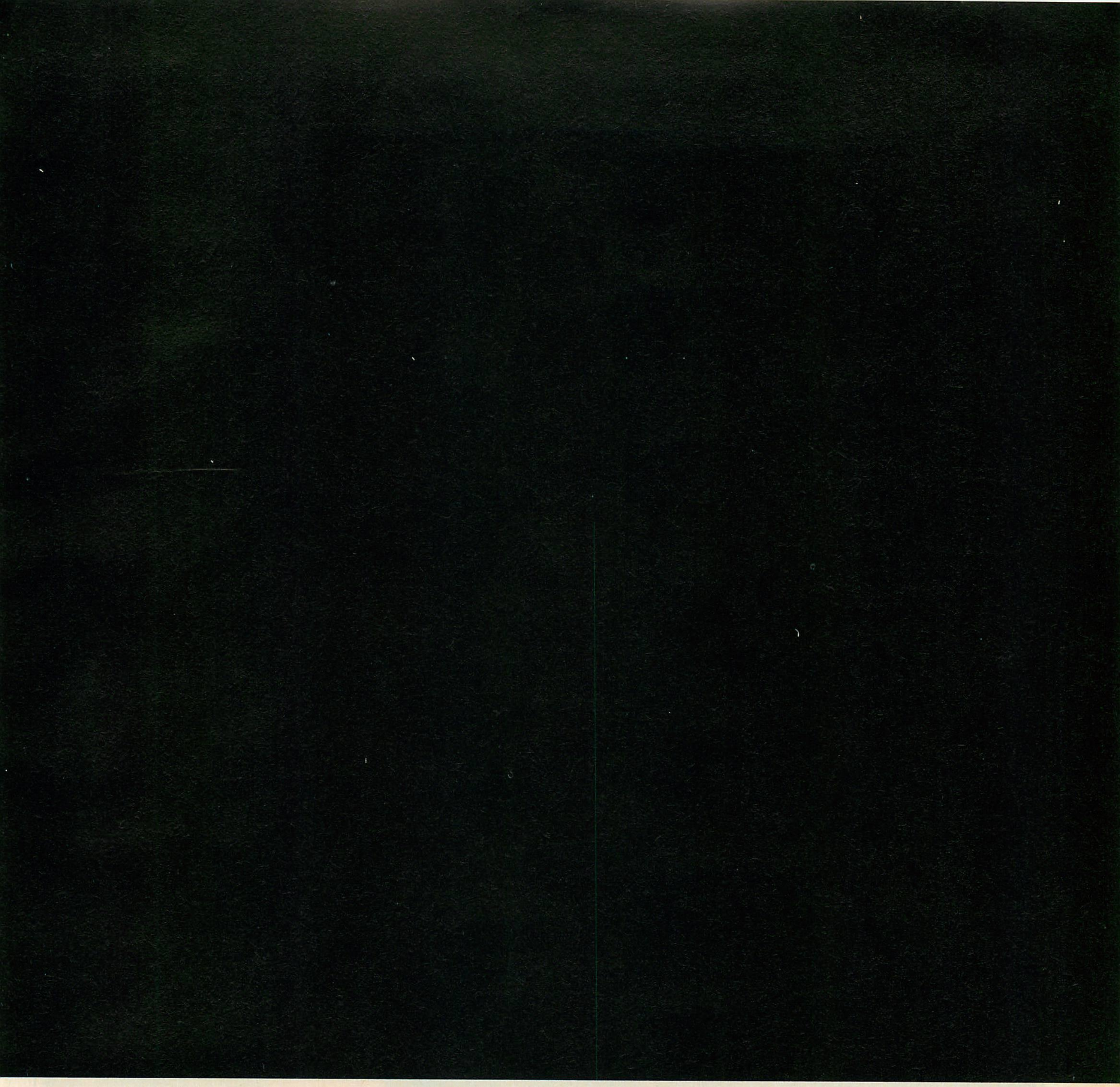

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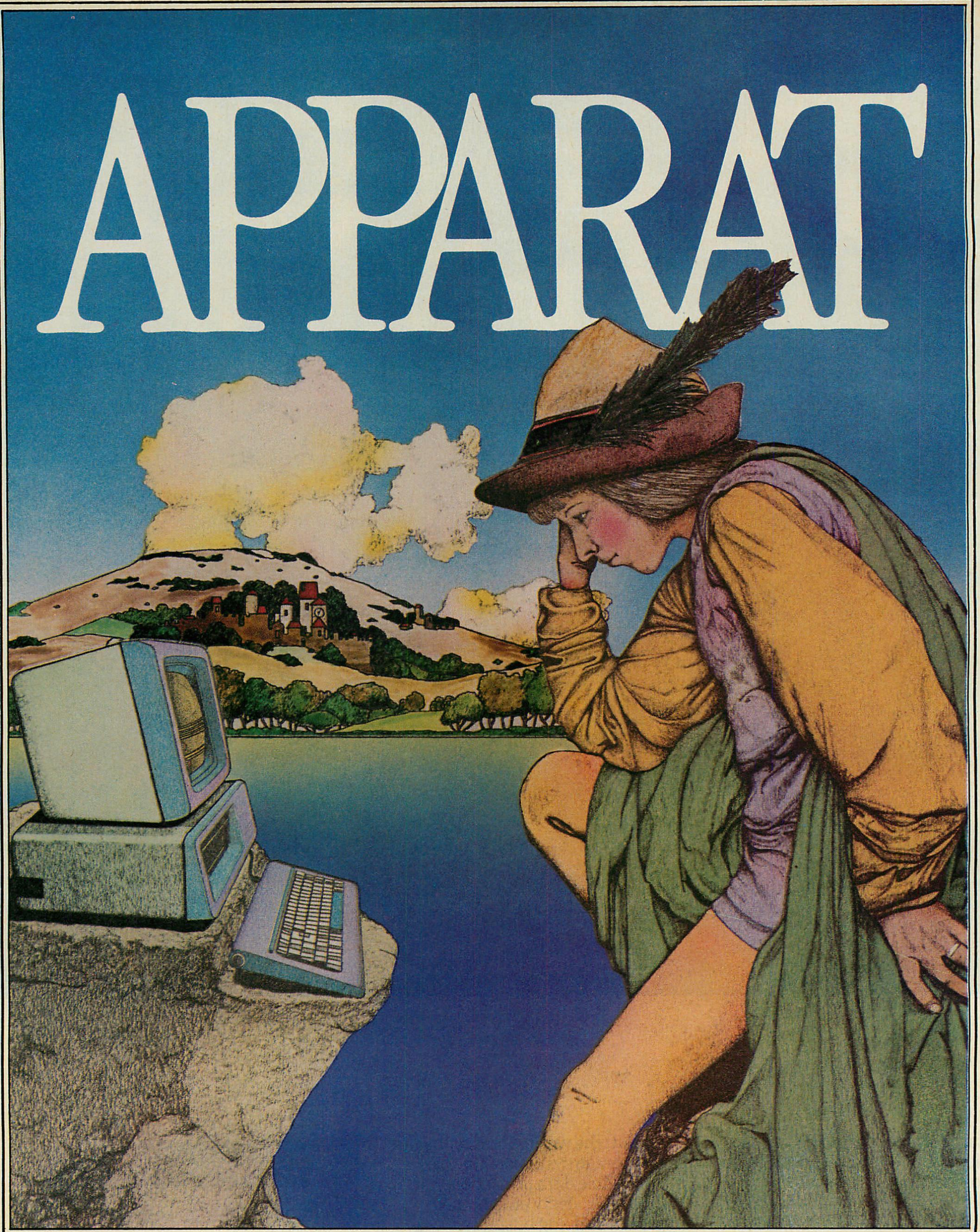

APPARAT

IBM and Graphics

Although IBM did not announce a new display subsystem along with the AT, it did so about a month later. In fact, it announced two.

The first, called The IBM Personal Computer Professional Graphics Display and Controller, is very expensive at $4,290 and is obviously designed for the serious graphics workstation. More information on this product can be found in the "Tech Releases" section in this issue, beginning on page 220.

The second, called The IBM Personal Computer Enhanced Graphics Adapter, is likely to become the most desirable display board for IBM systems. It will operate in any PC (except PC*jr*), although earlier PC models may require a ROM BIOS upgrade kit (IBM part number 1501005). The adapter is complicated to explain because it can do so much: it drives the IBM Color Display (model 5153) or other RGB monitors in the standard PC modes, IBM's new Enhanced Color Display (5154) with higher resolution and more colors or the IBM Monochrome Display (5151) in both text and graphics modes. The standard color graphics modes are also enhanced by the new controller, allowing the use of 16 colors in both medium and high resolution.

Even the pricing of this new adapter is complicated. The base price of $524 buys complete support for the 5151 and 5153, but another $199 must be invested in the Graphics Memory Expansion Card to fully exploit the 16 colors out of a palette of 64 with the enhanced display's 640 x 350 resolution. Another $259 option, the Graphics Memory Module Kit, expands graphics memory to its maximum of 256KB and can be used for additional graphics capabilities. Therefore, the likely price for systems using the 5154 display is $723, with a $982 investment required for all features. The Enhanced Color Display lists for $849, yielding a top-of-the-line subsystem price of $1,831.

The accompanying table should help to clarify price versus capability.

—*WF*

TABLE: *Prices and Capabilities of the Enhanced Graphics Adapter*

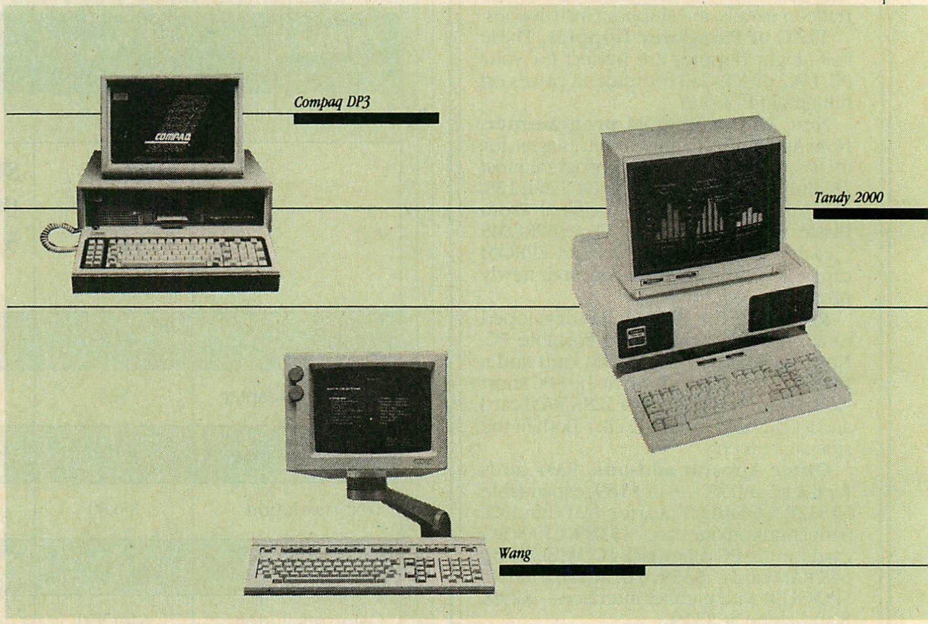
	DISPLAY TYPE			
	MONO-CHROME 5151	**STANDARD COLOR 5153**	**EN-HANCED COLOR 5154**	**EN-HANCED COLOR 5154**
Display	$275	$680	$849	$849
Enhanced adapter	524	524	524	723
Subsystem cost	$799	$1,204	$1,373	$1,572
Text resolution	25x80	25x80	25x80	25x80
Character box size	9x14	8x8	8x14	8x14
Color resolution	640x350	320x200	640x350*	640x350*
Number of colors	2	16 640x200 16	4	16

* The enhanced color system supports both standard color modes with 16 colors.

TABLE 3: *Features of Competing Systems*

COMPUTER SYSTEM					
FEATURE	**Wang PC**	**Tandy 2000**	**Compaq DP3**	**MAD-1**	**PC/AT**
Processor	8086	80186	8086	80186	80286
Clock Rate	8MHz	8MHz	7.177MHz	6MHz	6MHz
8087	no	no	option	no	option (80287)
Max RAM	640	768	640	512	640[1]
Disk Drives					
Diskette	1 x 360	1 x 720	2 x 360	1 x 360	1 x 1,250
Fixed	10 or 30MB	10MB	10MB	10MB	20MB
Operating System	MS-DOS 2.1	MS-DOS 2.11	MS-DOS 2.1	MS-DOS 2.0	IBM-DOS 3.0
Expansion Slots	5	4	4	none	7
Serial port	std	std	std	std (two)	std
Parallel port	std	std	std	std	std
Graphics[2]					
Color	640 x 250	640 x 400	320 x 200	640 x 200	320 x 200
# colors	16	8	4	16	4
Monochrome	800 x 300	640 x 400	640 x 200	720 x 350	none

[1] Under DOS 3.0. Up to 3MB may be used with other operating systems.
[2] Shown for least expensive option. New IBM Enhanced Graphics Adapter supports additional features.



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20333 FM 149
Houston, TX 77070
713/370-7040
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MAD-1
MAD Computer, Inc.
2950 Zanker
San Jose, CA 95134
408/943-1711
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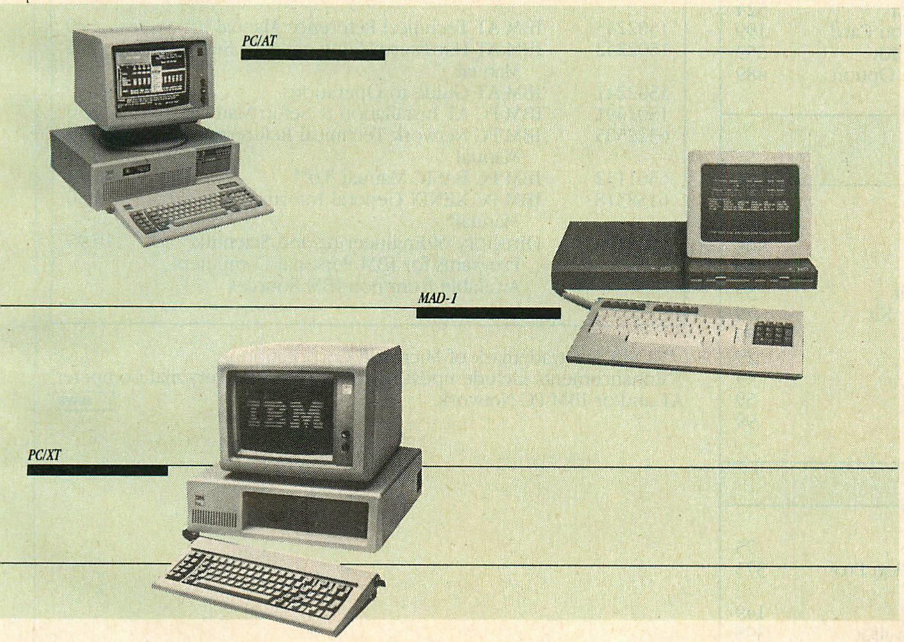
TABLE 4: *The Price of Competition*

	COMPUTER SYSTEM						
SYSTEM COMPONENT	**AT[1]**	**XT**	**DP3**	**Tandy**	**MAD[2]**	**Wang 5A**	**Wang 6A[3]**
Base unit	5,795	4,395	4,995	4,250	6,295	5,280	7,265
640KB	350	930	510	1,297		1,040	1,040
1 x 360KB 1 x 10MB Graphics[4]	924	924		698			
O/S, BASIC	65	60	60		195		
Total	7,134	6,309	5,565	6,245	6,490	6,320	8,305
Difference from AT		-825	-1,569	-889	-644	-814	1,171

[1]The AT includes a 20MB disk.
[2]MAD supports only 512KB of memory.
[3]Wang 6A includes a 30MB disk.
[4]Graphics means the least expensive way to obtain graphics, whether monochrome or color.

All systems are configured, if possible, to match the configuration of a standard XT. If the base price does not include an item, the cost to upgrade the system to the level shown is given.



Tandy TRS-80 Model 2000
Radio Shack
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Forth Worth, TX 76102
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Wang PC
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Lowell, MA 01851
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TABLE 5: *IBM Product Center Price List*

PART NUMBER	SYSTEM	PRICE
5170068	IBM Personal Computer AT with 256KB, 1.2MB Diskette Drive	$3,995
5170099	IBM Personal Computer AT (Enhanced) with 512KB, 1.2MB Diskette Drive, 20MB Fixed Disk Drive, Serial/Parallel Adapter	5,795
	NEW HARDWARE OPTIONS	
6450209	IBM AT 128KB Memory Expansion Option	350
6450202	IBM AT 256KB Memory Module Kit	495
6450203	IBM AT 512KB Memory Expansion Option	1,125
6450206	IBM AT 1.2MB Diskette Drive Option	650
6450205	IBM AT 20MB Fixed-Disk Drive Option	1,595
6450207	IBM AT 360KB Diskette Drive Option	425
6450211	IBM AT 80287 Math Coprocessor	375
6450215	IBM AT Serial/Parallel Adapter	150
6450217	IBM AT Serial Adapter Cable	65
6450242	IBM AT Serial Adapter Connector	35
6450218	IBM AT Floor Standing Enclosure	165
6450220	IBM AT Protype Adapter	35
6450216	IBM PC Display Stand	69
5175001	IBM PC Professional Graphics Display	1,295
6451501	IBM PC Professional Graphics Controller	2,995
6451502	IBM PC Data Acquisition and Control Adapter	1,275
6451504	IBM PC Data Acquisition and Control Adapter Distribution Panel	245
6451503	IBM PC General Purpose Interface Bus Adapter	395
5154001	IBM PC Enhanced Color Display	849
1501200	IBM PC Enhanced Graphics Adapter	524
1501201	IBM PC Graphics Memory Expansion Card	199
1501203	IBM PC Graphics Memory Module Kit	259
1501209	IBM PC 256KB Memory Expansion Option	489
	IBM PERSONAL COMPUTER NETWORK HARDWARE	
6450213	IBM PC Network Adapter	695
5178001	IBM PC Network Translator Unit	595
6450230	IBM PC Network Base Expander	59
6450231	IBM PC Network Short-Distance Kit	39
6450232	IBM PC Network Medium-Distance Kit	79
6450233	IBM PC Network Long-Distance Kit	89
6450234	IBM PC Network 25-Foot Cable	29
6450235	IBM PC Network 50-Foot Cable	39
6450236	IBM PC Network 100-Foot Cable	59
6450237	IBM PC Network 200-Foot Cable	99
	SOFTWARE APPLICATIONS	
6024195	IBM PC Network Program	75
6024036	IBM PC Network SNA 3270 Emulation Program	375
6024131	IBM PC TopView	149
6024133	IBM PC TopView Programmer's ToolKit	395
6024198	IBM PC DisplayWrite 2, 1.1**	299
	(Trade up from 1.0 to 1.1)	30
6024197	IBM PC DisplayWrite Medical Support	165
6024210	IBM PC DisplayComm Binary Synchronous Communications 1.1**	375
	(Trade up from 1.0 to 1.1)	35
6024193	IBM Macro Assembler 2.0**	175
	(Trade up from 1.0 to 2.0)	75
6024160	Office Correspondence Retrieval System	149
6024143	Professional Debug Facility	150

PART NUMBER	SYSTEM	PRICE
6024119	Application Display Management System	150
3100007	Application Display Management System Redistribution	100
6024196	IBM PC Computer Graphics DEVELOPMENT Toolkit	350
6024205	IBM PC Graphical File System	175
6024203	IBM PC Graphical Kernel System	295
6024204	IBM PC Plotting System	225
6024206	IBM PC Graphics Terminal Emulator	295
6451504	IBM PC Computer Data Aquisition and Control Adapter Programming Support	160
6024201	IBM PC General Purpose Interface Bus Adapter Programming Support	85
6024200	IBM PC Professional FORTRAN	595
	OPERATING SYSTEMS	
6024180	IBM PC-DOS 3.0**	65
6024181	IBM PC-DOS 3.0 Technical Reference Manual**	40
6024211	IBM PC-DOS 3.1**	30
	(Trade up from 3.0)	30
6024207	IBM PC XENIX Operating System*	395
6024209	IBM PC XENIX Software Development System*	455
6024208	IBM PC XENIX Text Formatting System*	145
	PUBLICATIONS	
1502243	IBM AT Technical Reference Manual	30
1502242	IBM AT Hardware Maintenance & Service Manual	295
1502241	IBM AT Guide to Operations	49.50
1502491	IBM PC AT Installation & Setup Manual	29.50
6322505	IBM PC Network Technical Reference Manual	195
6361132	IBM PC BASIC Manual 3.0**	40
6138318	IBM PC XENIX General Information Manual*	1.50
6024194	Directory of Engineering and Scientific Programs for IBM Personal Computers Available from non-IBM Sources	10.95

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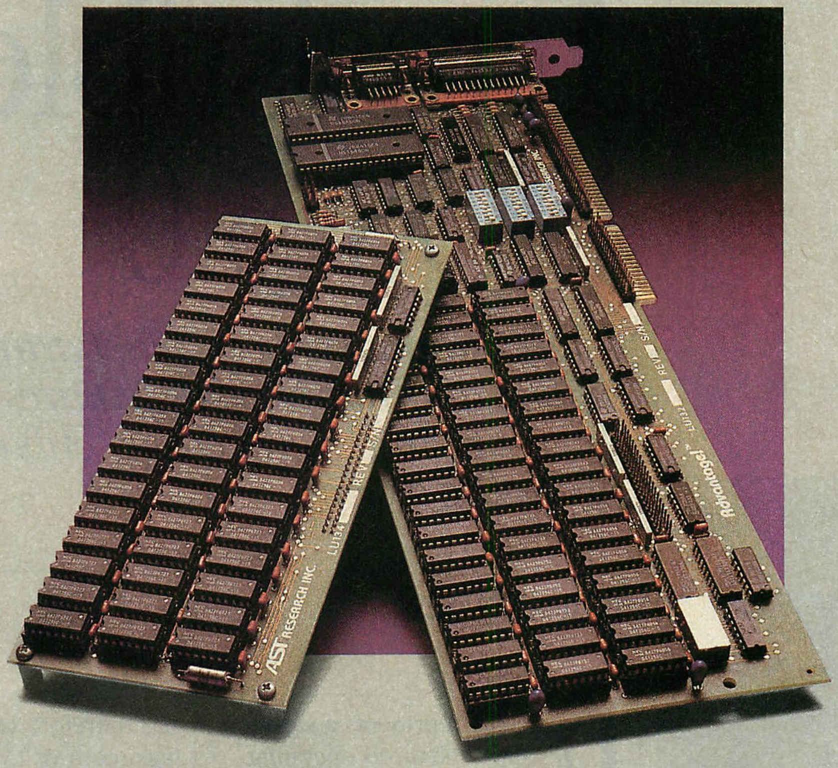

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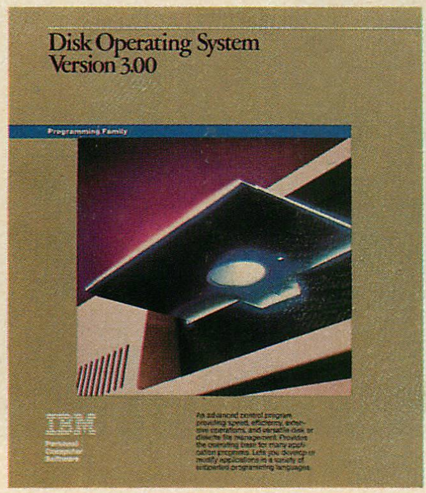

JULIE ANDERSON

DOS 3.0 represents a significantly enhanced operating system while still retaining compatibility with DOS 2.1. Its international support and file sharing capabilities alone make it irresistible. But DOS 3.0 has so many other useful features that it is hard to imagine anyone not wanting to use it, unless, of course, memory is a real problem.

Although introduced at the same time IBM announced the PC/AT, DOS 3.0 is not written just for the new machine, but is designed to run on any member of the IBM PC family. Changes were made so that DOS could support the AT's new hardware, the high-capacity disk drive, and the 20MB fixed disk, but for the sake of compatibility across all PCs, some design restrictions arose. DOS 3.0 runs on the AT in the 80286 Real Address Mode, and therefore can access only a maximum of 1MB of memory.

DOS 3.0 is upwardly compatible with DOS 2.1 but does not replace it, one reason being that DOS 3.0 is substantially bigger. Because DOS 3.0 requires at least 36KB of memory (DOS 2.1 requires 24KB), IBM recommends that minimum user memory be 96KB—or 128KB with a fixed disk.

Because its size has been increased so dramatically, DOS is now supplied on two double-sided diskettes as opposed to the single-sided diskettes used for previous DOS releases. One reason for the increase in size is that many parts of the operating system appear to have been rewritten in the C language. Also, much of the network support promised for DOS 3.1 is already installed, including file sharing and file locking.

Table 1 summarizes the new and enhanced commands, interrupts, and function calls of DOS 3.0, as well as the new BASIC commands included in the new release.

INTERNATIONAL SUPPORT

DOS 3.0 supports date, time, and currency formats for 15 different countries and supplies five foreign keyboard layouts. Selecting the country using the new COUNTRY command in the configuration file, CONFIG.SYS, causes a set of date, time, and currency format parameters to be loaded. The format of the COUNTRY command is

COUNTRY = xxx

where xxx is the three-digit international country code for the telephone system. For example, the country code for France is 033.

The appropriate keyboard layout is selected by loading any of the five keyboard programs supplied on the DOS 3.0 diskette. They are named KEYBxx.COM where the xx is UK (United Kingdom), GR (Germany), FR (France), IT (Italy), or SP (Spain). Each keyboard program runs as a resident program (using approximately 2KB of memory) and supersedes the ROM BIOS keyboard program.

Pressing Ctrl-Alt-F1 for US and Ctrl-Alt-F2 for the selected keyboard layout allows the user to switch between the two keyboard layouts. Each layout is defined in the *AT Technical Reference Manual* on pages 4-17 through 4-22.

A new DOS set-up command, SELECT, can be used to select one of six country and keyboard codes. SELECT makes a copy of the DOS system diskette by executing DISKCOPY and DISKCOMP. It then creates a CONFIG.SYS file containing the appropriate COUNTRY command, and an AUTOEXEC.BAT file containing a command to load the selected keyboard program. Obviously, this is useful only when the system is first installed, because any

TABLE 1: *New or Enhanced DOS Commands and Interrupts*

DOS EXTERNAL COMMANDS		
ATTRIB	New	Sets read-only attribute
BACKUP	Enhanced	Supports combination of media
DISKCOMP	Enhanced	Supports high-capacity drives
DISKCOPY	Enhanced	Supports high-capacity drives
FORMAT	Enhanced	Supports high-capacity drives
KEYBFR	New	Keyboard program for France
KEYBGR	New	Keyboard program for Germany
KEYBIT	New	Keyboard program for Italy
KEYBSP	New	Keyboard program for Spain
KEYBUK	New	Keyboard program for United Kingdom
GRAFTABL	New	Supports extended characters in graphics mode
GRAPHICS	Enhanced	Supports more printers
LABEL	New	Changes volume label
PRINT	Enhanced	Accepts performance tuning parameters
RESTORE	Enhanced	Supports combination of media
SELECT	New	Sets country and keyboard layout
SHARE	New	Enables file sharing
DOS CONFIGURATION COMMANDS		
COUNTRY	New	Selects country-dependent information
FCBS	New	Sets maximum number of FCBs
LASTDRIVE	New	Sets maximum number of block devices
DOS FUNCTION CALLS		
38	Enhanced	Gets or sets country-dependent data
3D	Enhanced	Opens a file for sharing
44	Enhanced	Added IOCTL functions
59	New	Gets extended error information
5A	New	Creates a temporary file
5B	New	Creates a new file
5C	New	Locks or unlocks a file
62	New	Gets program segment prefix address
DOS INTERRUPTS		
24	Enhanced	Improved error handling
2F	New	Communicates with print handler
BASIC COMMANDS		
ENVIRON ENVIRON$	New	Sets and gets environment parameters
IOCTL IOCTL$	New	Communicates with installed device drivers
ERDEV ERDEV$	New	Reports errors from critical error handler
SHELL	New	Executes a program from BASIC

existing CONFIG.SYS and AUTOEXEC.BAT files are deleted. It simplifies the installation process for the novice, however.

The country can also be selected under program control via the DOS Interrupt 21H function call 38H, Get or Set Country Dependent Information. The Set subfunction allows the user to choose the current country, while the Get subfunction returns a table of information on the current country. Table 2 shows the information returned for each of the six major countries.

Further international support is provided through the GRAFTABL program and an enhancement to the SORT filter. If the resident program, GRAFTABL, is loaded, it is

possible for the Color/Graphics Adapter to display the ASCII characters 128 through 255 in graphics mode. GRAFTABL increases the resident size of DOS by 1,200 bytes. SORT now collates foreign characters in correspondence to their English counterparts; that is, all European forms of the letter *a* are considered equal to the ASCII character 65; all European forms of the letter *e* are considered equal to the ASCII character 69, and so on.

Even the directory structure has been altered to support file names composed of foreign characters. The Greek character *sigma* is an E5H, the normal file-deleted indicator. If a file name begins with E5H, the first character will be stored in the directory entry as 05H.

FILE SHARING

In preparation for the IBM PC Network, DOS 3.0 supports a rudimentary level of file-sharing support. There is no ownership of files; access to files is determined on a first-come, first-served basis, and the first user to open a file determines how it will be shared. File locking is available down to the byte level and is active. Deadlocks are avoided because a system call resulting in a sharing conflict will fail after it has been retried a specified number of times.

Before files can be shared, DOS support must be installed by issuing the new DOS command, SHARE. This command allocates memory for DOS's file-sharing tables (default = 2KB) and for file locks. Each lock requires enough memory to hold the file name plus 11 bytes. When sharing is enabled, DOS checks all read and write requests against access restrictions.

Sharing of files is managed at the DOS-user program interface when the file is opened. The DOS Interrupt 21H function call 3DH, Open a File, has been significantly enhanced. On entry AL now holds the open mode, which specifies file-sharing information as well as the type of I/O to be performed on the file by this opener—that is, whether the file is to be written to, read from, or both. It is also possible to specify whether or not the sharing restrictions are to be passed on to a child process. Five sharing modes are recognized: Compatibility, Deny Write, Deny Read, Deny Read/Write, and Deny None.

In readiness for the IBM PC Network, DOS 3.0 supports a rudimentary level of file-sharing support.

The type of access allowed for a subsequent opening of a file depends on its current open mode and on the setting of the file's read-only attribute. If a file is opened in Compatibility mode and does not have the read-only attribute set, no sharing restrictions are placed on it except that it may be opened concurrently only in Compatibility mode. If the read-only attribute is set, DOS adjusts the sharing mode by changing any request for Compatibility mode to Deny Write and returning an error on an attempt to open the file for writing.

The Open File function call has been modified in such a way that programs written before DOS 3.0 are compatible with the new format. Files that are opened using the pre-3.0 format default to Compatibility mode. The values in AL that specified the type of read and write access are still valid. Sharing information and file access restrictions will, by default, be inherited by a child process. A file opened using the 0FH function call, FCB File Open, is automatically opened in Compatibility mode.

A file may be opened in Deny Write mode if it has not been previously opened allowing write access. Once opened in Deny Write mode, the file may not be written to by any other process.

Similarly, a file may be opened in Deny Read mode if it has not been previously opened allowing read access. Once opened in Deny Read mode, the file may not be read by any other process. If a file is opened in Deny Read/Write mode, exclusive access is granted; the file may not be opened again in any mode until it is closed.

The Deny None mode does not restrict access to a file at all. This mode is invalid if the file is already open in Compatibility mode.

The table on page 5-99 in the *DOS Technical Reference Manual* shows all valid sharing modes for subsequent opens on a file. Most valid sharing modes are reasonable. If a file is open for both input and output in Deny Read mode, the only other valid open mode is output in Deny None mode. Some unlikely, yet valid, combinations are possible, however. For instance, a file that is opened for input in Deny Read mode may be opened for output in Deny Write mode.

Locking is possible on all or part of a file. Using the new DOS function call 5CH, Lock/Unlock File Access, a region of a file is defined by giving an offset and length to lock or unlock. Other processes cannot access the file area for reading or writing while it is locked. If an attempt is made to access an area that is locked, the system call will be retried three times before failing. Unfortunately, locks are not released automatically when a file is closed or when the program issuing the lock terminates. This is the user's responsibility and can cause unpredictable or undesirable results if the locks are not released.

When file sharing is enabled, DOS maintains a least recently used chain of FCBs. When all users of a

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TABLE 2: *Country-dependent Information*

COUNTRY	UNITED STATES	FRANCE	SPAIN	ITALY	UNITED KINGDOM	GERMANY
Country code	001	033	034	039	044	049
Keyboard code	US	FR	SP	IT	UK	GR
Date format	m-d-y	d-m-y	d-m-y	d-m-y	d-m-y	d-m-y
Currency symbol	$	F	₧	Lit.	£	DM
Thousands separator	,	.	.	,	.	.
Decimal separator	.	,	,	,	.	,
Date separator	-	/	/	/	-	.
Time separator	:	:	:	:	:	.
Currency format						
Symbol precedes (p) or follows (f) value	p	f	f	p	p	p
Number of spaces between currency and value	0	1	1	0	0	0
Significant decimal digits	2	2	2	0	2	2
24- or 12-hour clock	12	24	24	24	24	24
Data list separator	,	;	;	;	,	;

file have closed it, the FCB's space in the chain is freed. References to the same file are considered to be one FCB. Because space must be allocated to the FCB chain when DOS is booted, a new FCB command is available in the CONFIG.SYS to specify the maximum number of files that can be open concurrently. The format of the FCB command is

FCBS = m,n

where *m* is the number of files opened concurrently by FCBs (from 1 to 255). Through experimentation I found that each FCB over the default of four increases the resident size of DOS by 56 bytes.

In the FCB command, *n* is the number of files (from 0 to 255, defaulting to 0) protected from being closed by DOS when the maximum number of FCBs are opened and a request to open another is received. Normally, the least recently used FCB is closed, and any subsequent attempt to access that file results in an error.

The FCBS command is only meaningful with file sharing. There is no limit to the number of FCBs without sharing. This also has no effect on the number of files that can be accessed using file handles. That limit is specified by the FILES= command in the CONFIG.SYS file.

VDISK—A VIRTUAL DISK

Although IBM has tacitly acknowledged the popularity of RAM disks by including the listing of a sample virtual disk device driver in the DOS 2.0 manual and providing a virtual disk with the new PC*jr* memory expansion unit, this is the first time an installable virtual disk device driver has been supplied with DOS. The virtual disk device consists of a device driver, which increases the resident size of DOS by approximately 720 bytes, and a disk buffer. If more than 1MB of memory is installed on an AT, one or

The virtual disk is installed by placing the DEVICE = command in the CONFIG.SYS file.

more disk buffers can be placed in extended memory. The device driver is always run in low memory.

The virtual disk is installed by placing the DEVICE = command in the CONFIG.SYS file. The amount of memory to be used, sector size, and number of directory entries are controlled by parameters included on the command line

DEVICE = VDISK.SYS [bbb][sss][ddd][/E]

where *bbb* is the amount of memory in kilobytes to use for the disk buffer. The default is 64KB, but anything from 1KB to all of the available memory is valid. The actual size used is adjusted so that at least 64KB of available memory is left after VDISK is installed. The minimum VDISK must be large enough to hold a boot sector, one copy of the FAT, one directory sector, and one data cluster.

The sector size is *sss*: 128, 256, or 512 bytes. If no sector size is given, 128 will be used. If the number of allocation units cannot be represented in 12 bits, the sector size is first increased up to the maximum of 512, then the cluster size is increased until the number of FAT entries <= 4,095.

The number of root directory entries is *ddd*: 2 to 512. If no number is given, the default is 64. The number of directory entries is rounded to fill out a complete sector. (Each directory entry is 32 bytes long, and one directory entry is always used for the volume label.) If not enough memory is

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available, the directory size is then adjusted downwards.

If the /E parameter is present, the disk buffer is placed in extended memory (above 1MB). This parameter is only valid on the AT.

When VDISK is installed, it displays a message giving its drive letter, final buffer size, sector size, and number of directory entries.

The file VDISK.LST, supplied on the DOS Supplementary Diskette, is a listing of the VDISK device driver. It serves as a sample device driver.

INSTALLABLE DEVICE DRIVERS

A new limit of 26 has been set on the number of block devices. The default is five, but a new configuration command, LASTDRIVE, can be used in the CONFIG.SYS file to increase the maximum to the system limit. This is the only area where some existing capability was removed, since DOS 2.1 permits 63 block devices. It is easy to see why the change was made. Twenty-six block devices should be adequate on any single PC. And logistically speaking, naming the block devices is a problem. The first 26 are named A through Z, but devices 27 through 63 end up with peculiar names like <, /, and >.

The method of retrieving the parameters passed to the device driver through the DEVICE = command in the CONFIG.SYS file is now documented so that the INIT routine can access this information. Also, the INIT function call request header has a new field added. DOS passes the device driver the drive letter of the first unit handled by the device driver.

A few changes have been made to the device driver interface to communicate whether the device is removable and to aid the driver in determining when a removable device has been changed. Three new function calls have been added: Device Open (13), Device Close (14), and Removable Media (15).

TABLE 3: *DOS 3.0 Formatting Parameters*

	TOTAL SECTORS	SECTORS/ CLUSTER	SECTORS/ FAT	SECTORS/ ROOT DIR	MAX ENTRIES/ ROOT DIR
Single-sided diskette 8 sectors/track 160KB	320	1	1	4	64
Single-sided diskette 9 sectors/track 180KB	360	1	2	4	64
Double-sided diskette 8 sectors/track 320KB	640	2	1	7	112
Double-sided diskette 9 sectors/track 360KB	720	2	2	7	112
High-capacity diskette 15 sectors/track 1.2MB	2,400	1	7	14	224
XT fixed disk 17 sectors/track 10MB	20,723	8	8	32	512
AT fixed disk 17 sectors/track 20MB	41,735	4	41	32	512

The Removable Media call is made to removable block devices when an IOCTL operation is requested. A new bit has been added to the device header attribute field indicating whether the device is removable: bit 11 = 1 means the device is removable, 0 means nonremovable. In response to the Removable Media call, the driver should set the busy bit (bit 9) in the status word if the device is nonremovable and reset the busy bit if the device is removable.

Some enhancements to DOS were necessary in order to support the higher capacity disk drives of the AT.

For removable block devices, the new function calls Device Open and Device Close can be used as a buffering aid. The driver can maintain a count of open files, incrementing the count on each open call and decrementing on each close. When the count reaches 0, all modified buffers should be written to the device so that the media can be removed without any data loss. The open count can also help to determine if an illegal disk change has occurred. If so, the operator can be requested to reinsert the previous volume.

For character devices, the Open call can be used to initialize the device or to reset the device before an I/O operation. Similarly, the Close call can be used to send some post-processing commands after I/O is performed.

A new error code, 0FH, invalid disk change, has been added to the status word of the request header. If the driver determines that the disk has been changed illegally, it should return this error and set the volume id field pointer to the correct volume name.

DOS DISK STRUCTURE

Some enhancements to DOS were necessary to support the higher capacity disk drives of the AT. With fixed disks larger than 10MB, it is possible to build DOS partitions with more than 4,096 clusters, the largest number respresentable in 12 bits. To accommodate these drives without increasing the cluster size, FAT entries can now be 16 bits long. The DOS Syst Ind field in the boot record partition table of the fixed disk indicates whether the FAT entries are 12 or 16 bits. This also allows the cluster size on the 20MB fixed disk to be a more efficient four sectors rather than the space-wasting eight used for the 10MB drive. Curiously, cluster size on the new high-capacity drive (1.2 MB) is one sector. Table 3 shows the formatting parameters used for each of the drive types that DOS 3.0 supports. For each fixed disk, the entire disk was allocated to one DOS partition. Other DOS partition sizes may yield different results.

The FORMAT, DISKCOPY, and DISKCOMP commands have all been modified to handle the higher capacity drives. The /4 parameter has been added to the FORMAT command so that double-sided diskettes (320KB or 360KB) can be formatted in a high-capacity diskette drive. The usefulness of this capability is limited since once a double-sided diskette is written to in a high-capacity drive, it cannot be reliably read in a double-sided drive.

When a fixed disk is formatted, a new message appears: "Warning. All data on Non-removable Disk drive C: will be lost! Proceed with Format? (Y/N)?" instead of the previous message: "Press any key to begin formatting drive C:". This helps the user avoid inadvertently reformatting fixed disks. In addition to begin formatting a diskette, the user must press Enter, rather than just "any key."

The BACKUP and RESTORE commands allow more combina-

tions of media. It is now possible to back up and restore to any combination of fixed disks and diskettes as long as the source and destination are not the same drive. If file sharing is enabled, then only files to which the user has access can be backed up. BACKUP and RESTORE may return the completion code, ERRORLEVEL = 2, which indicates that not all files were backed up or restored because of file sharing.

GENERAL ENHANCEMENTS

A long-awaited feature is finally included in DOS 3.0. Executable files (.COM, .EXE, and .BAT) can now be invoked using path names. Therefore, instead of being limited to invoking programs that are either in the current directory or able to be found through the predefined path, it is now possible to give the path of the program at execution time. For example,

```
C:\UTIL\FORMAT A:
```

is now a valid command.

A valuable new feature for software developers is the ability of a program to determine the directory from which it was invoked. The path name of the program file currently being executed is now available through the Program Segment Prefix. This information can be used by a program to find its ancillary files, such as a help file or overlay files. The address of the Program Segment Prefix can be obtained by a new DOS function call 62H, Get Program Segment Prefix Address. Offset 2CH in the PSP points to the beginning of the environment. Immediately following the environment strings is a count (word length) followed by the name of the program invoked. If the program were found in the default directory or if the program were invoked with a path name, then the file name would be stored as passed to the EXEC function call. If DOS found the program through the path, then the drive letter and path precede the file name. This information would be easier to retrieve if DOS could place it directly in the PSP. IBM probably chose this awkward method to achieve compatibility with other DOS versions.

TABLE 4: *New Parameters for PRINT Command*

/D: device	Print device (default = prn)
/B: buffsiz	Size of print buffer (default = 512)
/Q: quesiz	Number of files in queue 1-32 (default = 10)
/S: timeslice	Number of time slices 1-255 (default = 8)
/U: busvtick	Number of clock ticks to wait if printer is busy; if elapsed, give up time slice 1 - 255 (default = 1)
/M: maxtick	Max clock ticks to use to print 1-255 (default = 2)

OTHER CHANGES TO THE CONFIGURATION FILE

On the AT, DOS reserves space for three buffers, whereas on other PCs it reserves space for two. The BUFFERS command in the CONFIG.SYS file still allows the default to be overridden. Each buffer used in addition to the default increases the resident size of DOS by 528 bytes.

The previously undocumented SWITCHAR command can no longer be used in the CONFIG.SYS file. Removing undocumented commands is, of course, the prerogative of the operating system developer, as the user of an undocumented command realizes. In DOS 2.0 the SWITCHAR command changed the switch character from the default of "/" to whatever the user specified. There were those who preferred to use a "-" as does UNIX. Unfortunately, not all DOS commands, most notably the RESTORE command, recognized the new switch character and problems ensued. (See "A Fix for DOS Users with UNIX Habits," and "Patchwork," *PC Tech Journal*, August 1984, pages 73 and 113, respectively.)

OTHER NEW DOS COMMANDS

The ATTRIB command can be used to add, remove, or display the read-only attribute of a file. If the read-only attribute is set, an attempt to COPY the file returns a "File creation error," and an attempt to delete the file returns the message, "Access denied." Other file attributes cannot be displayed or modified with ATTRIB.

The LABEL command can change or delete a volume name and can add a volume label to a disk not formatted with the /V option. Unfortunately, LABEL does not display the existing volume name; the VOL command must be used to see the current volume label.

More printers are supported with the GRAPHICS program, including the IBM Personal Computer Color Printer with either black, RGB (red, green, blue, black), or CMY (cyan, magenta, yellow, black) ribbon, the IBM Personal Computer Compact Printer, and the IBM Personal Computer Graphics Printer. If no printer is specified, the graphics printer is assumed.

The installed print handler can now be user-customized by specifying various performance tuning parameters. Those parameters permitted with the PRINT command are shown in table 4.

Missing from DOS 3.0 for the AT is a way to set the system clock from DOS. Although the DATE and TIME commands change the current copy of the time, they do not alter the system clock. The system clock can be modified only by using the set-up program on the diagnostic diskette or through a BIOS system call. The DOS DATE and TIME commands should check to

see if DOS is running on an AT, and if so, issue the BIOS interrupt 1AH to set the system clock. We consider this oversight suprising, considering IBM's normal attention to detail. "Setting the PC/AT's Time and Date" on page 57 in this issue provides a program for setting the AT system clock from DOS.

CHANGES TO INTERRUPTS

The 24H Critical Error Interrupt can be handled cooperatively by DOS and the user. When the user program initializes its critical error handler routine, it should save the original vector address. Then when the user's handler is given control, it issues a CALL FAR to the original vector address. DOS will notify the operator of the error and pass control back to the user's critical error handler. The user's routine issues an IRET when it has finished.

On entry to the Critical Error Handler Routine, bits 3-5 in AH now indicate the valid responses to a disk hard error—that is, whether FAIL, IGNORE, or RETRY are valid. If a critical error has occurred on a FAT or directory sector, the ignore response is invalid and will be changed to fail. When the handler executes an IRET, it may return a new code in AL. If AL = 3, DOS will cause the system call that is in progress to fail.

The Printer Interrupt 2FH allows communication with the installed print handler. Depending on the value of AL, it is possible to get the installed state of the print handler, submit a single file to be printed (no global file name characters are accepted), scan the print queue, hold or release the queue, cancel a single file, or cancel all of the files in the queue.

DOS FUNCTION CALLS

Error processing has taken a major step forward in DOS 3.0. Any time a DOS function call sets the carry bit to indicate an error, or an 0FFH is returned from an FCB function call,

or the INT 24H Critical Error Handler is invoked, the new DOS function call 59H, Get Extended Error, should be issued. This function call returns an error code, class, locus value, and suggested action. This method has several advantages. A standard set of errors can be defined for all system calls. More specific errors can be returned to the user so that his diagnosis of the problem can be made easier. And finally, the fact is recognized that the action a program takes in response to an error depends in many cases on the type of error rather than on the specific error.

Two new DOS function calls are a critical addition for multiuser processing and networks: Create a Temporary File (5AH) and Create a New File (5BH). The first one creates a file with a unique name. The file is not opened and is not automatically deleted when the program ends. File names are formed from the ASCII representation of the current time in hexadecimal. For instance, a file created at 2:32 p.m. was given the name 0E201154. With a name like that, there should be little chance of duplication even in a multiuser environment. If a duplicate file name is created, however, DOS keeps trying until a unique file name is found. DOS Pipes are now created with these temporary file names; the previous file names, %PIPEx.$$$, could cause conflicts with multiple users.

Similarly, Create a New File creates a file named by the user only if the file does not already exist. This can be used to avoid deleting another user's file by accident. The file is opened in Compatibility mode for reading and writing.

The function call, 44H. I/O Control for Devices (IOCTL) has two new subfunctions added: request if device is removable—(AL = 08H), and change sharing retry count (AL = 0BH). If a sharing conflict occurs, the user can specify the number of retries as well as the time interval between retries.

Newly documented in DOS 3.0 are the differences in binary versus ASCII I/O to the standard input and output devices.

WHAT'S IN STORE FOR 3.1?

Network support will be completed in DOS 3.1. Three new commands will be added to DOS in the newer version: JOIN, SUBSTITUTE, and APPEND. JOIN will allow a drive to be attached to a directory as a subdirectory; SUBSTITUTE will allow the use of alias names for a subdirectory path; and APPEND will do for file name opens what PATH does for finding executable files.

Several new function calls for the PC Network will be added; they

will return installation information and manage redirection.

Function call 5EH will have two subfunctions: Get Machine Name and Setup Printer Control String. Function call 5FH will have three subfunctions: Get Assign List Entry, Redirect Device to Net, and Cancel Redirection. Two new subfunctions will be added to the IOCTL function call 44H, Is Device Redirected, and Is Handle Local or Remote.

If a duplicate file name is created, however, DOS keeps trying until a unique file name is found.

BOTTOM LINE

As the first paragraph of this review admits, I find DOS 3.0 irresistible, because of its international support, file-sharing capabilities, and a great many other useful features. Whether you should buy 3.0 or wait for 3.1 depends on whether you plan to use the PC Network. If so, 3.1 is a must. If you do not see the network in your future, 3.0 will be sufficient. If you decide later to use the network, the penalty is only the $30 upgrade cost.

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IBM Corporation
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CIRCLE 496 ON READER SERVICE CARD

New Commands in BASIC 3.0

Each of the so-called new commands in BASIC 3.0 existed in one form or another, although undocumented, in BASIC 2.0. The keywords were listed in the BASIC 2.0 reserved words list and worked with varying degrees of reliability.

ENVIRON and ENVIRON$. The ENVIRON command and the ENVIRON$ function provide a method to set and retrieve parameters in the environment. When BASIC is invoked, the current environment is made available to the BASIC program. This environment can be queried, changed, or expanded to the next 16-byte paragraph boundary, then passed on to a child of BASIC.

The ENVIRON$ function retrieves values from the environment either by parameter name or number. The command

PRINT ENVIRON$("PATH")

will print the current path. Notice that lower-case and upper-case letters are not considered equal: ENVIRON$("PATH") and ENVIRON$("path") refer to different parameters.

Sometimes it is useful to operate on the environment as a whole. Without knowing the names of each parameter, the entire environment can be saved, modified, and then restored by issuing the ENVIRON$(n) form of the function. ENVIRON$(1) returns the name and value of the first parameter. This can be issued repetitively, incrementing *n* until a null string is returned.

To set the value of a parameter, use the following:

ENVIRON "parameter = value".

BASIC's environment string processing appears to have a bug. If there are any blanks between the parameter name and the equal sign, the equal sign becomes part of the value returned by the ENVIRON$ function. Because of this processing anomaly, the example on page 83 of the BASIC 3.0 manual actually does not work as shown. In the example, reproduced below, the path of a help directory is added to the environment. Then the current directory is changed to the value of the help directory.

ENVIRON "HELP = C:\ HELP"
CHDIR ENVIRON$ ("HELP")

However, the CHDIR command fails because the value of the parameter HELP was set to "= C:\HELP", not "C:\ HELP" as intended. To work properly, the ENVIRON statement should be coded without any intervening blanks. To remove a parameter from the environment, use

ENVIRON "parameter=;" or "parameter="

Again spaces count. If the command is coded as follows

ENVIRON "parameter = ;"

the parameter is not removed from the environment, but instead is given the value of "= ;".

IOCTL and IOCTL$. The IOCTL statement and the IOCTL$ function communicate control information to a user-installed device driver. This is comparable to the DOS function call 44H subfunctions 02H, 03H, 04H, and 05H. IOCTL sends control information to the device driver—for instance, to change the baud rate for a character device. IOCTL$ reads control information from the device driver, such as device status.

ERDEV and ERDEV$. After the INT 24H critical error handler has intercepted an error from a device, the read-only variables ERDEV and ERDEV$ hold the error code and device name respectively. The low order byte of ERDEV contains the INT 24H error code, and bits 13, 14, and 15 contain the corresponding bits of the attribute word of the device header block. For a character device, ERDEV$ contains the device name. For a block device, ERDEV$ contains the drive letter followed by a colon.

SHELL

With limitations and caveats to the user galore, the SHELL command has appeared in the BASIC manual. SHELL allows the temporary execution of a child process from BASIC. When the child process terminates, BASIC resumes execution at the statement after the SHELL command.

If SHELL is invoked without parameters, COMMAND.COM is loaded and executed as if the /C parameter were given. DOS commands can then be executed at will until the EXIT command is issued to return the user to BASIC. SHELL can be invoked with a string parameter containing the name of a program to run as well as any parameters.

Alas, the restrictions for the successful use of SHELL are many. The state of an executing program is composed of many elements: open files, screen mode settings, interrupt vectors, etc. The child process can alter the state of any of these conditions, inducing unpredictable results when the parent process is resumed. As in life, it is generally the parent's responsibility to undo any damage the child process may inflict. The parent must ensure that the child process does not alter any of the conditions that are necessary for the successful execution of the parent.

BASIC saves and restores the interrupt vectors it uses, but any interrupt vectors that have been modified by the parent must also be restored. Also, BASIC does not automatically save and restore the screen mode that was in effect before the child process was invoked.

All files should be closed before the SHELL command is executed. Files opened that redirect input or output are passed to the child and cannot be closed. If these are altered by the child, data may be lost.

A program that terminates but stays resident cannot be executed using SHELL, because BASIC may not be able to restore its workspace. Finally, BASIC cannot be a child of BASIC because it stores information about the current program in low memory. A new copy of BASIC would overwrite this information, making resumption of the parent BASIC impossible. —*JA*


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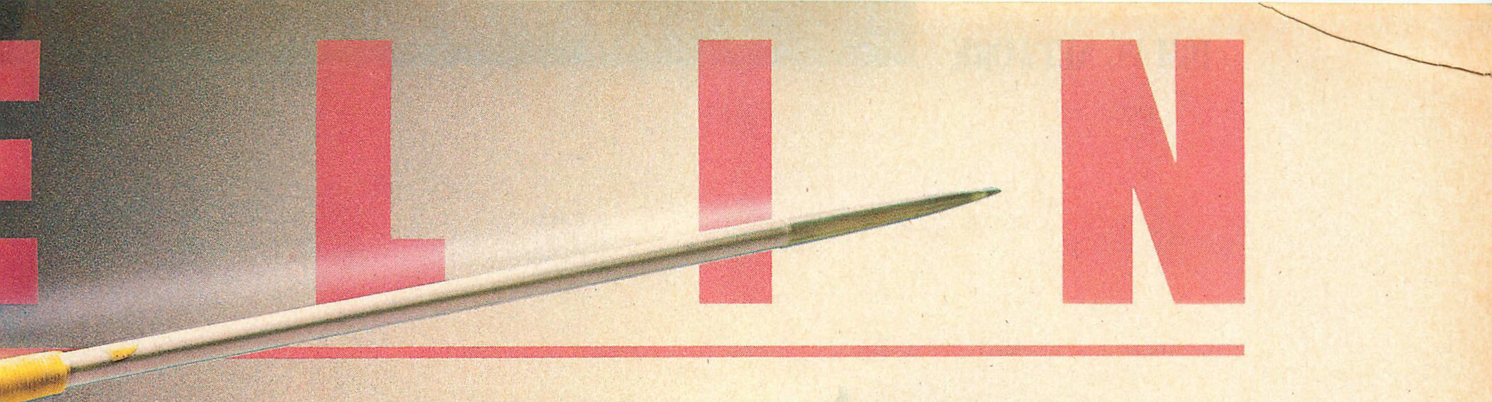

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*The Small Computer System Interface (SCSI) is an interface standard that specifies the mechanical, electrical and functional requirements for a small computer I/O bus interface and command set for peripheral devices commonly used with small computers.

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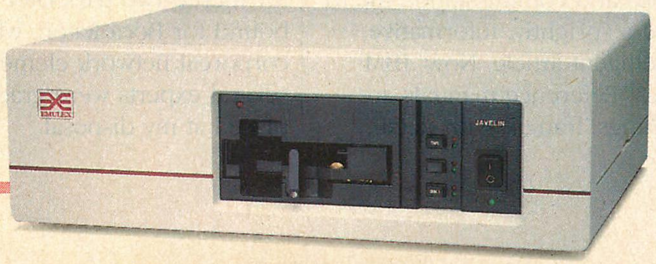


A Network for all Reasons

The IBM PC Network offers flexibility, expansion capacity, and interfaces appropriate to a wide range of users.

SUSAN GLINERT-COLE

Concurrent with the announcement of the PC/AT, IBM introduced a network. Although this product has all of the requisite wires, boards, protocols, and topologies of a network, it isn't to be confused with *the* IBM network, which is supposed to appear in about three years and for which IBM has released only wiring plans. At the time of this writing, it is possible to offer only an overview of this newly introduced network; the corporeal elements of the set-up have yet to materialize.

When our editor first conceived the idea of this article, he confidently placed a copy of the PC *Hardware Technical Reference* in my hands and commissioned me to produce a sprightly, informative, and intelligent article. Now, IBM Technical Reference manuals are many things: fraught with detail, pregnant with meaning, terse, pithy, and so on. They are not, however, the best clay from which to mold a sprighty, informative, and intelligent article. One problem in particular stood head and shoulders above the rest: except for a few coy references, the hardware manual contained absolutely no information about network software.

Three days later, our editor stopped by my office to inquire after my progress only to find me biting the desk in an effort to infuse a modicum of sprightliness into a sentence revolving around gas-expanded polyethylene dielectric coaxial cable. My dental exercise was correctly interpreted as a cry for mercy; two days later I was bound for Boca Raton, where the corporeal network elements and several experts were graciously placed at my disposal.

A COST-COMPETITIVE AND FLEXIBLE NETWORK

The IBM PC Network shown in figure 1 is designed to be cost-competitive and flexible. To this end, it uses broadband, as opposed to the more common baseband, technology to provide peer-to-peer information transfer. Even without the added flexibility that broadband technology provides, the $695 price per network-adapter card would still be competitive. The network hardware components have been kept as simple as possible: a network card that incorporates a unique node ID; standard CATV coaxial cable; and low-maintenance, prebalanced connection hardware.

The standard hardware will support a network of 72 nodes with a maximum length of 2,000 feet end-to-end. If a more complex arrangement is desired, the IBM PC

Network Hardware Technical Reference manual maintains the open-system concept (the hallmark of the IBM PC family) and provides the professional network designer with complete information on all facets of the hardware. Such a professionally designed network can be expanded to 1,000 PCs, with a maximum radius of five kilometers.

The maximum network speed is two megabits per second, but this number is important only for getting on and off the wire, as multiple fixed-disk access is more likely to limit network throughput than is the speed across the wire. IBM attributes an estimated 10-percent performance loss to the fixed disk. Adapter performance is illustrated in figures 2 and 3.

The most important feature of the IBM PC Network, distinguishing it from all other local area networks on the market today for the IBM PC, is that the network-software support is part of the operating system. Hitherto, third-party LANs provided software that either replaced PC-DOS or interposed itself between the applications software and DOS. Having the network programmer's interface integrated into the standard working environment is a boon to software developers, who can now use a coherent set of tools and be assured of reasonable compatibilty across the PC family.

IBM PCs, PC/XTs, Portables, and PC/ATs can all participate in this network. PC*jr* is not supported. Each computer on the network requires at least 128KB of memory, one double-sided disk drive, an 80-column display, and DOS 3.1. Computers that are designated as file/print servers require, in addition, 256KB of memory; a printer is required only for print-server functions. Each node also must have a network-adapter card installed.

The user interface to the network is provided in the IBM PC Network Program. Other operating systems, such as XENIX, CP/M, and the UCSD p-System, are not directly supported, but development houses can write device drivers that can talk to the network-adapter card.

Contention on the network is arbitrated with a CSMA/CD protocol. A jumper on the adapter card can be configured to use either interrupt 2 or 3. DMA is usually used to transfer data from the computer to the adapter card. The I/O address space is jumper-selectable at 360H to 367H or 368H to 36FH.

Rather than the more commonly used baseband technology, IBM chose to use broadband transmission. Broadband allows exchange of voice, data, video, etc. over the same cable. Broadband networks use different frequencies to provide a simultaneous communications link to all nodes.

The network has been designed as strictly peer-to-peer; no central file or print servers are needed. This design maintains the personal-computer philosophy while allowing data sharing. As many as 32 sessions (the number of machines with which a node can be simultaneously conversing) are permitted. The session number defaults to 32, but is configurable downwards at the time of installation.

The network has been designed as strictly peer-to-peer; no central file or print servers are necessary.

Users can share fixed and floppy disks, files, printers, and modems (modems are treated as serial printer devices) across the network. IBM has not provided a comprehensive electronic mail facility, although messages of up to 1,600 characters can be composed, sent, and archived with a simple menu-driven message-editor program that is provided in the software.

BASIC COMPONENTS

The network hardware is comprised of three basic components: the network adapter, the network translator unit, and the network cabling kits. The network adapter contains all the hardware required to perform protocol processing through the session layer. The translator unit provides the single-channel frequency translation for the network. The cabling kits, which can be obtained in several different configurations, (for short, medium, and long distance), allow a flexible variety of network topologies to be installed. All kits are pretuned to make installation as simple as possible by dividing the balancing problems inherent in broadband systems.

The 3,000-MHz coaxial cable supports 50 channels, each 6 MHz wide. Only two of the channels are used in the plain-vanilla IBM PC Network; the RF modem transmits on one channel and receives on the second. This leaves 48 channels available for video, voice, and other data transfer, if the network is properly configured for these types of transmissions. The $695 price per network adapter card is thus competitive, even without the added flexibility of broadband technology.

Broadband and baseband networks cannot be mixed, so the IBM Cluster cannot be interfaced with the IBM PC Network. The IBM PC Network doesn't support PC*jr*s; for those who are desirous of having an AT commune with a PC*jr*, both the AT and the PC*jr* can participate in the Cluster. Alternatively, gateways between the Cluster and PC Network can be built by installing both adapter cards in a PC, PC/XT or PC/AT. (For a review of the IBM Cluster, see "Clusters of Wrath," Susan Glinert-Cole, *PC Tech Journal*, August 1984, page 64.)

NETWORK HARDWARE

The network hardware is divided into two classes of components: digital and RF modem (see figure 4). The former group is comprised of the following acronymic parts:

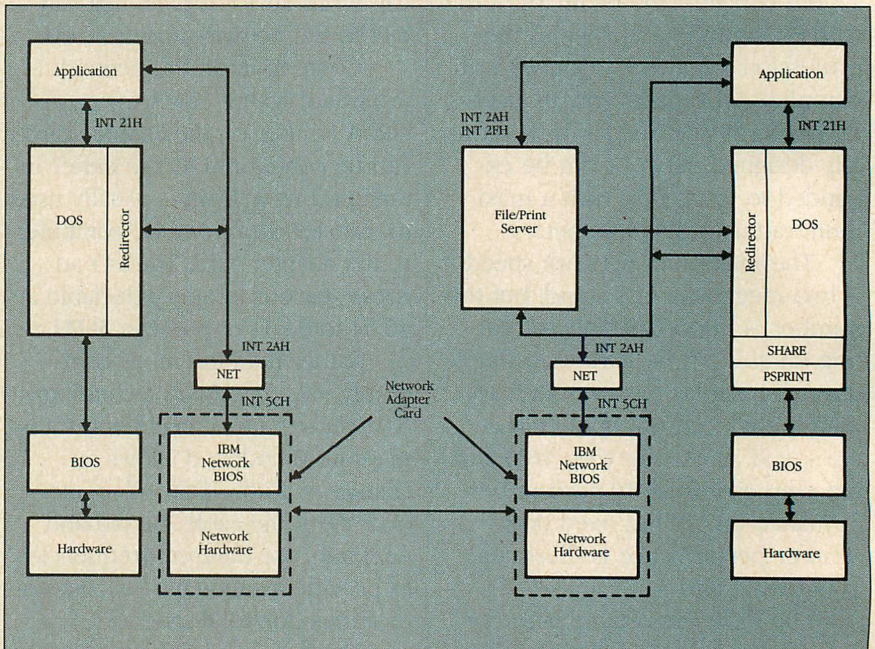
Intel 80188 microprocessor
The Personal Computer/Host Interface Controller (HIC)
Sytek Serial Interface Controller (SIC)
Intel 82586 Local Communications Controller (LCC)
16KB by 8 data RAM
32KB by 8 adapter ROM
32KB by 8 ID PROM
8KB by 8 BIOS ROM

Communication between the computer and the 80188 microprocessor is effected with interface circuits consisting of the HIC and ancillary TTL bus transceivers and drivers. The circuitry contains a set of interface registers and the control logic required to send data and commands. It allows a programmer to view the network-adapter card as a linear array of addresses.

The SCC and the LCC together make up the interface to the RF modem section of the network adapter. They are also responsible for implementing the link-layer protocols. The SCC interfaces to the 82586 controller and is responsible for NRZI encoding and decoding, clock recovery, collision and carrier/no-carrier detection, and carrier-sense control. The 82586 LCC transfers data to and from memory and packages it in an HDLC format. This coprocessor is also responsible for error recovery and retry, CSMA/CD protocol adherence, serialization of deserialized data, and link-level packet recognition.

The Intel 80188 microprocessor contains two DMA channels, programmable timers, a programmable interrupt controller, and bus-interface logic. One of the two DMA channels is used to transfer data between the interface registers in the HIC and a local memory buffer. Three memory-select signals are provided by the 80188 to select the three RAM/ROM chips.

FIGURE 1: *Network Overview*



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The LCC, SIC and HIC are selected by one of the three peripheral-select signals generated by the microprocessor. The 80188 responds to four external peripheral interrupts, this includes one interrupt each from the SIC and the LCC, and two from the HIC.

The firmware for the network adapter is comprised of two ROM chips and one PROM chip.

The 16KB dynamic RAM is used as an internal buffer for scratch memory, stacks, protocol control, and transient data.

The network adapter's firmware is comprised of two ROM chips and one PROM chip. The BIOS ROM (NETBIOS) is an extension of the network-support software. It can be accessed directly by the PC. It can also be disabled by removing a jumper, should it be desirable to place two network cards into one computer. The NETBIOS is the interface between applications programs and the interface controller (which in turn is the interface between the NETBIOS and the 80188).

Program and protocol information required by the 80188 is contained in the 32KB adapter ROM. Each adapter has a unique identification, coded in the PROM, by which it is known to the network.

The RF modem is comprised of a 50.75-MHz transmitter and a 219-MHz receiver. Each channel is 6 MHz wide and clean enough to coexist with video signals. Although the model is CATV-compatible in signal level and quality, most CATV networks have signal-level tolerances that will exceed that supported by this modem. This implies that only certain CATV channels can be used in conjunction with the IBM PC Network.

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A complete set of network-adapter diagnostics is built into the firmware. When a node is powered up, the following tests are performed: ROM, RAM, 80188, PC interface, digital loop-back, and cable loop-back. If the interface test fails, an error is generated and transmitted to the applications program by the participating PC. The interface is disabled, although the network adapter will remain active. All other test failures will deactivate the network adapter card.

Two types of on-line diagnostics are provided: missing-carrier detection and hot-carrier recognition. If a missing carrier is detected during transmission, the network adapter will report the error to the operating system. A hot carrier is the LAN equivalent of a road hog: a network-adapter card whose transmitter is continuously active. Because the CSMA/CD protocol listens for a pause before sending, a hot carrier on the line will not allow any other transmitter to broadcast. The absence of a pause is interpreted as a hot carrier by the network adapter, which then bypasses the CSMA/CD protocol and transmits a packet to itself through the hot carrier.

If the packet arrives garbled, the adapter informs the operating system that a hot carrier exists somewhere else on the network. If the packet is received correctly, the adapter card admits that it is the culprit. This information is available to the operator, who can then remove the offending node.

The adapter card is a repository for diagnostic information that can be examined locally or remotely. These statistics are always available: reporting period; self-test result; and counts of CRC error, alignment error, collision, transmission/retransmission, and reception.

FIGURE 2: *Adapter Performance Throughput*

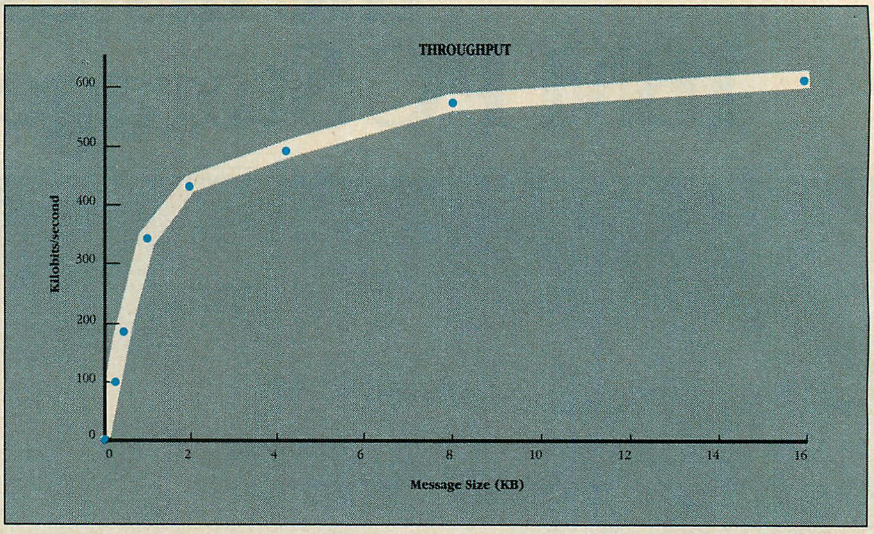
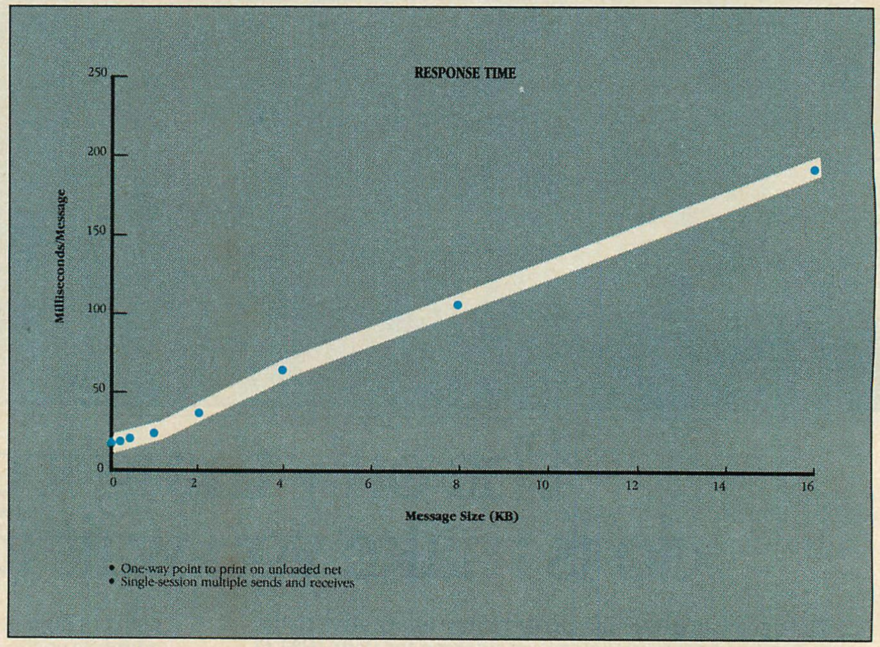


FIGURE 3: *Adapter Performance Response Time*



THE TRANSLATOR UNIT

Network-adapter cards transmit at 50 MHz and receive at 219 MHz; the translator takes the former signal and translates it to the latter. Only single-channel, passive, data-only networks are supported. One translator can support 256 PCs within a 1,000-foot radius if the load is appropriately balanced by a knowledgeable professional (see figure 5).

CABLE-SYSTEM COMPONENTS

The cabling scheme is based on the mystical "Way of Eight." Eight network adapter cards, separated by, at the most, 200 feet, can be attached to the translator unit via an eight-way splitter (see figure 6). For longer distances or more PCs, the expansion tap (provided with the translator-unit hardware) is connected to an eight-way base expander. Cable kits, each of which will support eight PCs, connect to

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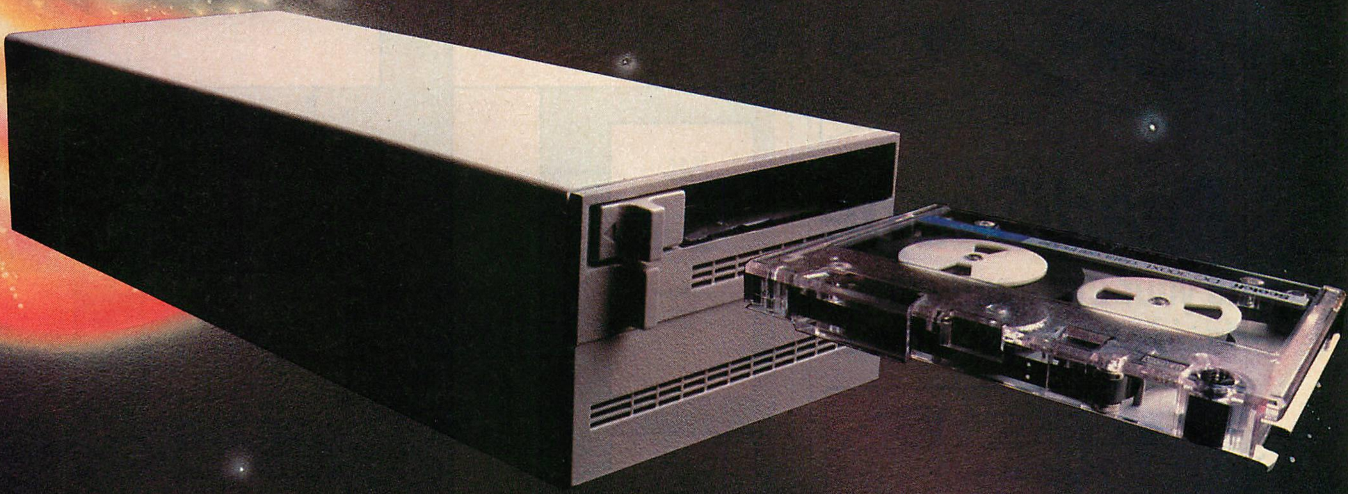

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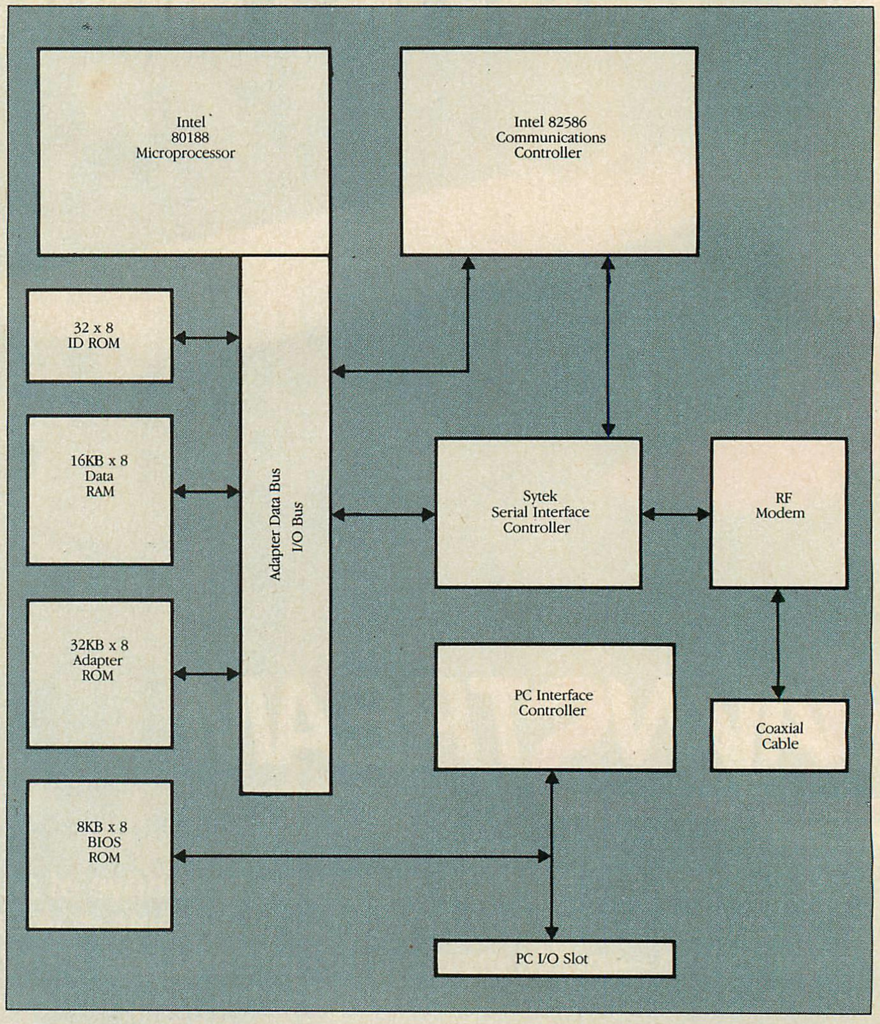
FIGURE 4: *IBM PC Network Adapter Block Diagram*



the taps on the base expander.

The three adapter kits are installed in the same way. They differ in the length allowed from the base expander: 1 foot for the short-distance kit, 400 feet for the medium-distance kit, and 800 feet for the long-distance kit. Cable segments are available from IBM in 25-, 100-, and 200-foot lengths, and there are specific rules regarding the ways in which longer lengths can be built from these units.

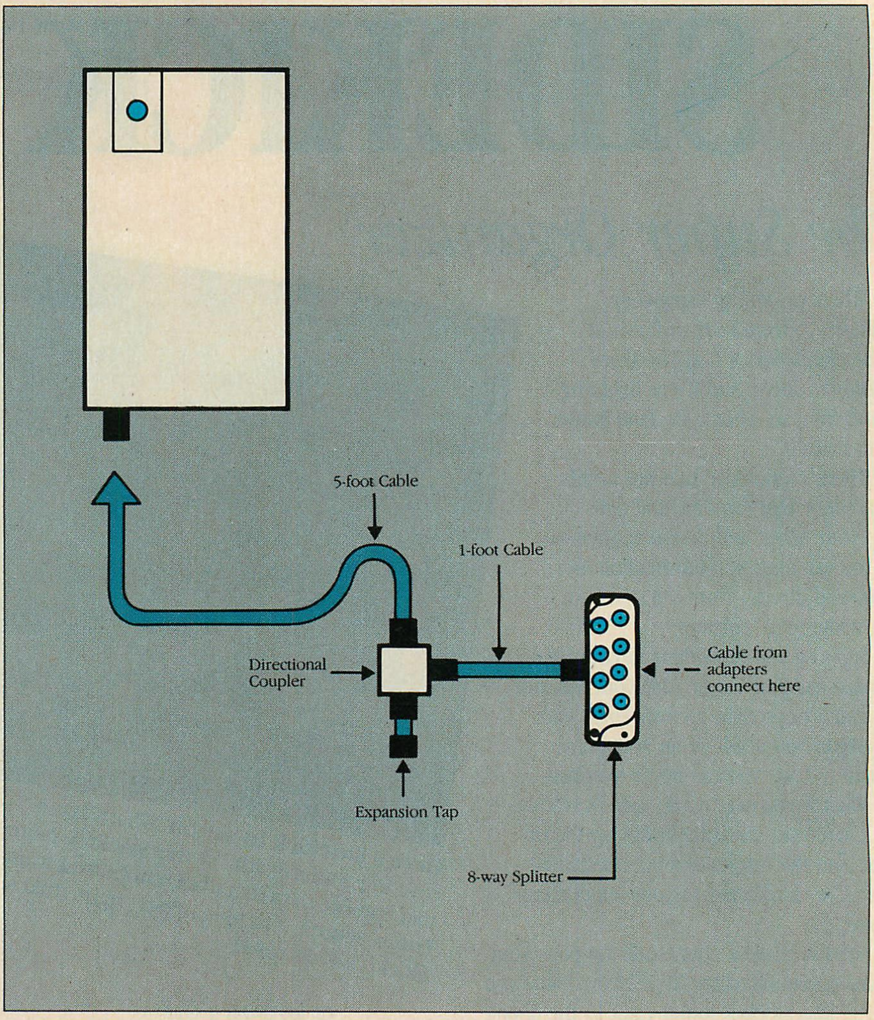
LOW-LEVEL HARDWARE

The first five layers of the ISO/OSI model are built into the network-adapter card. The physical layer, implemented with an RF modem and the SIC, provides throughput of two megabits per second. The modem transmits on one channel and receives on another.

The link layer has the responsibility of assembling bits received from the physical and network layers into data units. When the physical layer has received a transmission, the link layer checks and assembles the bits for further processing by the network layer. The link layer protocols are implemented by the SIC and the LCC on the network interface card.

The network layer is responsible for correct packet routing. It receives messages from the transport layer, selects a correct route, and passes the packet to the link layer for further processing. The network

FIGURE 5: *IBM PC Network Translator Unit Components*



layer also receives data units from the link layer, determines if it is a datagram or if it belongs to a virtual circuit, and then sends the packet on to the transport layer.

Establishment of reliable point-to-point connections between two network adapters is the primary responsibility of the transport layer. It supports data transmissions and acknowledgments and takes care of any flow control necessary to maintain a reliable connection.

The session layer implements the adapter interface in conjunction with the BIOS. Its responsibilities include establishing a session using two names from the name table, interpreting commands given in the form of a Network Control Block, and supporting multiple aliases for a single adapter. The programmer's interface presented by the session layer is discussed below.

NETWORK SOFTWARE

At the time of this writing, the IBM PC Network Program is still under development, with a release date scheduled for early 1985. This lack of documentation prevents me from providing a detailed description of the software.

The network program can be configured at each station to provide four different levels of participation. The redirector option permits local file I/O (interrupt 21H) and print requests (interrupt 17H) to be redirected over the network

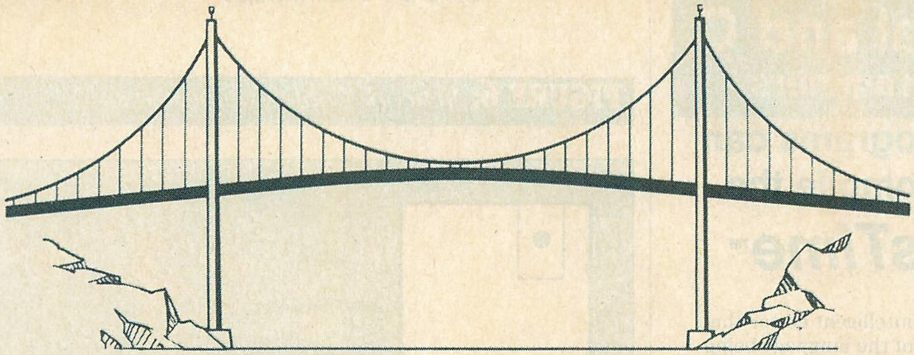


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FIGURE 6: *Network Cable Components*

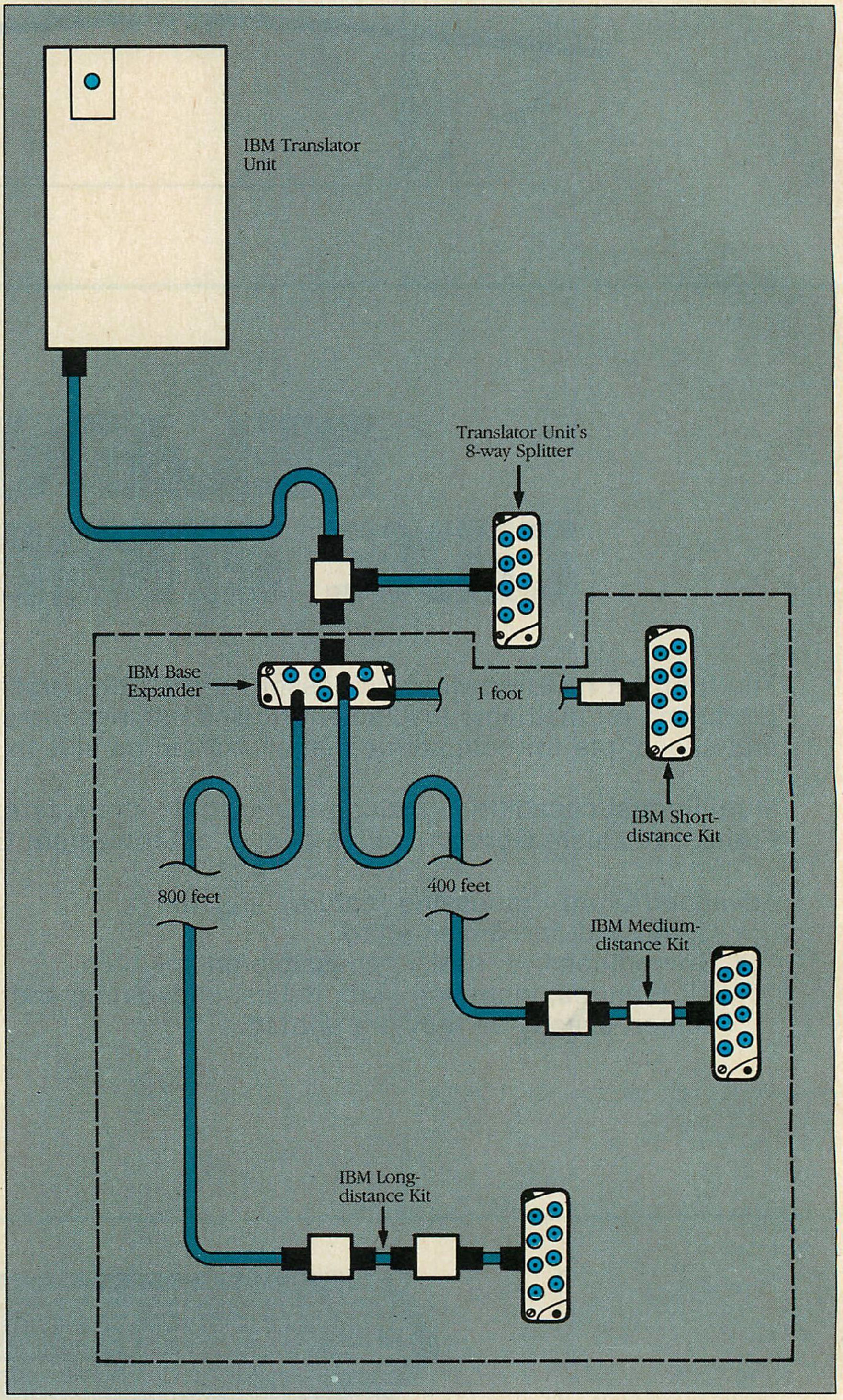

FIGURE 7: *Programmer's Interface*

Interrupt	AH	AL		Function
INT 21H	3D			Open file with sharing specified
	44	09	IOCTL	Is device redirected?
	44	0A	IOCTL	Is handle local or remote?
	44	0B	IOCTL	Change sharing retry count
	59			Get extended error
	5A			Create temp file with unique name
	5B			Create new file
	5C	00		Lock byte range
	5C	01		Unlock byte range
	5E	00		Get machine name
	5E	02		Set up printer control string
	5F	02		Get assign list entry
	5F	03		Redirect device to net
	5F	04		Cancel redirection

Interrupt	AH	Function
INT 2AH	00	Installation check
	01	Exec NETBIOS request
	02	Set net printer mode
	03	Get device shared status

Interrupt	AH	AL	Function
INT 2FH	BB	00	Net command installation check
	BB	03	Get server post address
	BB	04	Set server post address

The program interface to the IBM PC Network program consists of a set of interrupt calls that provide installation information and redirection control and status for application programs. This figure lists the functions by interrupt and function code(s).

to a file/printer server. Commands can be entered at the DOS prompt; the remote resources appear to the user as if they were attached to the local machine. The code for network redirection is not included in DOS 3.0, which is the primary reason why the network requires DOS 3.1 (or later).

A machine can also be configured as a receiver, allowing network messages to be received and sent to the screen, a printer, or a file. Message-handling is done in the background of a concurrently executing applications program.

The messenger function supplies a full-screen editor, which can handle messages of as many as 1,600 characters in length. In addition, other names, which can also be forwarded to another node, can be specified with this option. Messages can be composed, edited, transmitted, received, archived, and recalled from within the editor. For those hardy souls who eschew such features as menus, messages can be sent with a command that is typed at the DOS prompt.

If a PC is configured as a server, it can share both fixed and floppy disk drives, directories, and printers concurrently with a locally executing applications program. A maximum of three printers, or two printers and a modem, can be shared at each server. The print queue can hold no more than 100 files; print jobs are queued and executed in the background. Remote directories and drives appear to the

user as additional local drives.

A station can also allow its drives and devices to be shared in a single-session version of the file/print service using the PERMIT command. Although access by remote stations is identical to that of a genuine server, the local station cannot be used during the session for local jobs.

Directories and drives can be assigned access privileges on three levels: read, write, and create. Optional password protection is supported as well.

Three interface levels to the network program are provided. The casual user can use the full-screen, menu-oriented interface, which features on-line help and function keys for command entry. The more experienced user can enter network commands directly at the DOS command line; this interface is also used for batch file processing. The commands that can be used are listed in table 1. Applications programmers are provided with a program interface that allows access, via three interrupts, to low-level network functions, such as file locking and network status. Figure 7 illustrates the program interfaces.

The programmer interface for the network supplies system services at two levels: a set of new interrupts and/or function calls furnished with DOS 3.1 and the NETBIOS interface to the network adapter. The new DOS calls provide features appropriate to a multi-user environment, such as locking and unlocking disk storage areas, I/O redirection to remote stations, and ways to obtain network statistics.

The session layer provides a consistent command interface between the programmer and the network adapter card by using an NCB, in conjunction with interrupt 5CH. Communications sessions are established and maintained with this NETBIOS interface. The NCB, shown in figure 8, controls four cattegories of commands: general, name support, session support, and datagram support.

Once the NCB has been built, the command is sent to the network adapter by placing the block address into the ES:BX register pair and invoking the interrupt. After the command has been processed, control is returned to the calling program with the result of the processing in either the AL register or the return control field in the NCB.

There is no such thing as anonymous transmission in the network; all communications sessions require the use of names. In addition to the permanent node name, the network-adapter card can be known by the network by as many as 16 aliases. Three name-support com-

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FIGURE 8: *Network Control Block Field*

NETWORK CONTROL BLOCK (NCB) FORMAT

FIELD NAME	CODING AND MEANING		
NCB__COMMAND	DB 00H	;	NCB command field
NCB__RETCODE	DB 00H	;	NCB return code field
NCB__LSN	DB 00H	;	NCB local session number field
NCB__NUM	DB 00H	;	NCB number of your name
NCB__BUFFER@	DD 00000000H	; ;	NCB pointer to message buffer address (offset:segment)
NCB__LENGTH	DW 0000H	;	NCB buffer length (in bytes)
NCB__CALLNAME	DB 16 DUP(0)	; ; ; ; ;	NCB name on local or remote adapter. For CHAIN SEND, the first 2 bytes indicates length of second buffer. The next 4 bytes indicates the second buffer address.
NCB__NAME	DB 16DUP(0)	;	NCB name on local adapter.
NCB__RTO	DB 00H	;	NCB receive timeout value
NCB__STO	DB 00H	;	NCB send timeout value
NCB__POST@	DD 00000000H	; ;	NCB pointer to post routine. (offset: segment)
NCB__LANA__ NUM	DB 00H	; ; ;	NCB adapter number for first adapter. Use 01H for second adapter.
NCB__CMD__ CPLT	DB 00H	; ;	NCB command status field
NCB__RESERVE	DB 14DUP(0)	;	NCB reserved area

Note: An "@" is used to represent the word "address" in the above list of descriptions.

mands are available: ADD NAME, ADD GROUP NAME, and DELETE NAME. If the programmer prefers not to use the permanent node name, the alias must be added to the name table before the session can be established.

General commands are used to enable the adapter on the network, to read adapter on the network, to read adapter status, to reset the adapter, and to clear the name table.

Session-support commands are used to establish and maintain a communications session. A session is opened between two computers using their names and the LISTEN and CALL commands. Once established, the session is referenced with a one-byte session number returned in the NCB_LSN field after the open. Other, commands that are used for session support include SEND, CHAIN SEND (send the contents of several buffers sequentially), RECEIVE (from a specific session), RECEIVE ANY (from any session), SESSION STATUS, and the ever-useful HANGUP.

Datagram-support commands are usually used to broadcast a message to all network nodes, but they can also transmit to a specific name or group name. Unlike session-support commands, datagram messages are never acknowledged by the receiving adapter, and messages are limited to a maximum length of 512 bytes. Supported commands are SEND DATAGRAM, SEND BROADCAST DATAGRAM, RECEIVE DATAGRAM, and RECEIVE BROADCAST DATAGRAM.

The Remote Program Load (RPL) commands enable a computer to boot from a remote server. In effect, the NETBIOS redirects the initial diskette-read requests to the

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Each computer on the network requires a network card ($695), a Network Program License ($75), and a length of cable ($59 for 100 feet). One translator ($595) is also needed for each network. A minimally configured system, consisting of three computers, cable, and the translator, would cost $3,082. For each additional computer, up to eight (maximum length from computer to the eight-way splitter of 200 feet), the cost is incremented by $770 for the hardware, software, and cable.

If more than eight computers are needed, or if more than 200 feet is desired between the nodes and the splitter, one base expander must be purchased ($59). One distance kit (short, medium, or long) can link eight more nodes into the network by attaching to the base expander. (see figure 1). The expander can accommodate a total of eight distance kits. A medium cable kit ($79) and 200 feet of cable ($99), added to the price of the base expander, represents an additional modest investment of $158 for the ninth computer. Thereafter, every clutch of eight computers will require the small expenditure for a cable kit and a length of connecting cable.

—SG-C

TABLE 1: *Network Commands*

COMMAND	FUNCTION
NET START	Invokes one of the four Network Program Configurations
NET SHARE/NET USE	Share/use network resources
NET PAUSE/NET CONTINUE	Suspend/resume network operations
NET SEND	Send message(s)
NET LOG	Log message(s) to console, printer, or file
NET NAME	Add a name to the local name table for receiving messages
NET FORWARD	Forward a name to another machine so message(s) can be received there
NET PRINT	Print a file on a network printer or get print queue status
NET SEPARATOR	Define a separator page to be printed between print files on a printer server
NET ERROR	List the network-error log
NET FILE	List current users and current record locks for a file
MODE	Set network printer
PERMIT	Allow single-session version of a file server

This figure, as well as figures 2-5, is reproduced here by permission of IBM Corporation.

network if: (a) there are no other drives enabled and (b) the RPL jumper on the network adapter has been enabled. The boot requests are directed to a special name on the network called IBMNETBOOT. This node must be active on the network for remotely loading computers to access it.

RPL requests are independent of the operating system and can be used with any operating system that can use the RPL during initialization. The only caveat is that the operating system not perform direct diskette access; all diskette requests must be done with INT 13H.

Network security is not inherent in the BIOS; it is the programmer's responsibility to provide privacy and protection facilities using the appropriate locking and unlocking functions available from DOS.

CONCLUSIONS

IBM appears to have designed a network for all reasons: one that offers flexibility, expansion capacity, and interfaces appropriate to a wide range of users. By publishing the NETBIOS code and providing complete technical details for the network designer, IBM is inviting third-party developers to customize the IBM PC Network for a variety of uses. We look forward to the arrival of the actual network components for performance evaluation.

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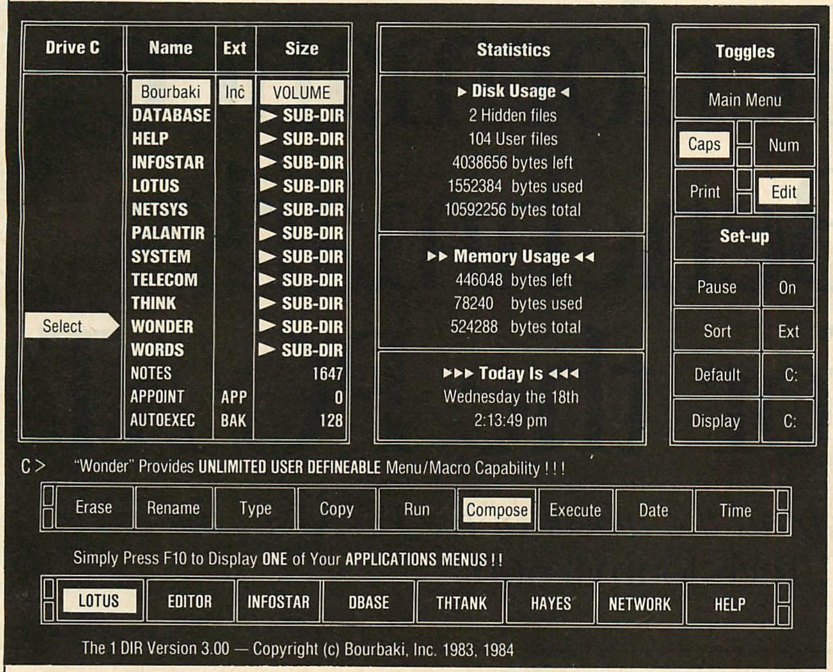

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VROOM! Performance Benchmarks for the PC/AT

Behind the wheel of the PC/AT in the PC Tech Journal *500*

SUSAN GLINERT-COLE

Never having been much enamored of speed, I prefer the more leisurely track: bicycles to motorcycles, sailboats to motorboats, and cross-country skiing to the downhill schuss. One should take the time to smell the flowers.

Now, while I have several flowering plants around the office, gathering a noseful of pollen every time I compile a program can be quite tedious, if not potentially allergenic. The figurative roar of an internal combustion engine would be most welcome in any CPU that I happen to be exercising.

It has therefore been a pleasurable experience to settle into the driver's seat of the PC/AT, snap on a set of dust goggles, and floor the return key. Never mind that one hand gripped a stopwatch and the other a pen instead of a gearshift and a steering wheel. The results of the *PC Tech Journal* 500 amply compensated for the lack of situational veracity, however.

It is difficult to perform precisely meaningful benchmarks on machines that are as different as the PC/XT and the PC/AT. Consider: the XT and the AT not only appear dissimilar, but differ in microprocessors, bus widths, disk drives, drive controllers, and operational characteristics at the electrical level. These differences are not to be confused with the fact that the AT, when in Real Mode, has been designed to be functionally and operationally compatible with the XT.

We have tried to infuse some substance into the tests by selecting benchmarks that are genuine tasks, such as loading word processors and compiling programs. We have run benchmarks from past issues of *PC Tech Journal* on an XT under DOS 2.0 and 3.0 and on an AT under 3.0. To minimize the effects of file fragmentation, the benchmark files were placed in the same order on a freshly formatted fixed disk in each series of tests.

The XT used for these benchmarks was a PC with two 360KB floppy disk drives, 512KB RAM, an IBM expansion chassis with two 10MB fixed-disk drives, and an AST Six-Pack Plus. The AT was equipped with one 360KB and one 1.2MB floppy-disk drive, one 20MB fixed-disk drive, and 640KB RAM.

The results (and references to the issues of the magazine in which the benchmarks first appeared) are presented in table 1. A general summary suggests that the AT is two to three times faster than the XT in almost all categories.

The random access I/O test (see table 1 for all benchmark

results) writes 50 records, within a 1,000-record file, to 50 other records. Each record is 50 bytes long. The sequential read test reads 641 lines, each 50 bytes long, within a 40,000-byte file. The sequential read/write test reads, and then writes, 641 50-byte lines to another file. These results, as well as the word processor benchmarks and the 100-yard Dash are all disk-intensive rather than CPU-intensive. The marked improvement in performance demonstrated by the AT in these cases can obviously be attributed to differences in the floppy and fixed disks. In particular, as can be seen in table 2, the smaller track-to-track seek time for the new disk drives, in conjunction with the smaller interleave factor for the AT fixed disk are mostly responsible for the enhanced performance.

Table 3, fixed-disk performance benchmarks (see "Fixed-disk Benchmarks," William Hunt, *PC Tech Journal,* November 1984, page 64) are intensively I/O bound. The first test reads a varying number of sequential sectors, and because of minimized seek time, reflects the effective data transfer rate of the disk drive. The second test performs random reads with a fixed track distance between each operation. These results reflect the variation of seek times between drives. While the 360KB floppy drives do not show much variation between the AT and XT, the 1.2MB drive is 20- to 30-percent faster than the 360KB drives. The 20MB fixed drive, as befits its racy image, has a two- to threefold performance enhancement over the 10MB drive.

The Lattice C compile times (in table 1) show an unusual performance difference under DOS 2.0 and DOS 3.0 on the XT. Lattice suggests that the improvement might be due to a better buffering algorithm within the 3.0 operating system. The operational characteristics of the Lattice compiler, which randomly rereads sectors during each

TABLE 1: *Benchmark Results*

BENCHMARK	PC/XT DOS 2.0 (Format 2.0)	PC/XT DOS 3.0 (Format 3.0)	PC/XT DOS 3.0 (VDISK)	PC/AT DOS 3.0 (Format 3.0)	PC/AT DOS 3.0 (VDISK)	RATIO OF PC/XT (2.0) TO PC/AT (3.0)	RESULTS PUBLISHED *PCTJ*
I/O							Jan. '84
random access	6	6	3	3	1	2.00	
sequential read/write	29	34	25	12	9	2.42	
sequential read	14	14	13	6	4	2.33	
WORD PROCESSOR (30,000-byte file)							Jan. '84
WordPerfect:							
load wp from hard disk	4	3	–	2	–	2.00	
load wp from floppy disk	14	9	–	6	–	2.33	
exit wp (to hard disk)	1	1	–	1	–	1.00	
load file from floppy	4	5	–	4	–	1.00	
save file to floppy	18	19	–	11	–	1.64	
load file from hard disk	2	1	–	1	–	2.00	
save file to hard disk	15	14	–	6	–	2.50	
WordStar:							
load wp from hard disk	6	5	–	3	–	2.00	
load wp from floppy disk	7	7	–	5	–	1.40	
exit wp (to hard disk)	0	0	–	0	–	1.00	
load file from floppy	3	4	–	3	–	1.00	
save file to floppy	32	32	–	28	–	1.14	
load file from hard disk	3	4	–	2	–	1.50	
save file to hard disk	10	9	–	5	–	2.00	
COMPILE/LINK							Nov./ Dec. '83
compile time (Lattice C, V2.0)							
sieve (60 lines)	29	13	9	5	4	5.80	
pentathlon (150 lines)	53	41	32	15	11	3.53	
link time (V2.0)							
sieve (60 lines)	21	21	16	8	5	2.63	
pentathlon (150 lines)	26	23	19	10	6	2.60	
PENTATHLON							
floating point (10 iterations)	48	48	48	17	18	2.82	Nov./ Dec. '83
function calls (10 iterations)	15	14	14	5	5	3.00	
string copy (10 iterations)	20	20	20	7	7	2.86	
character count (10 iterations)	16	16	16	6	6	2.67	
file copy (30,000 bytes, 2 iterations)	43	36	22	15	8	2.87	
100-YARD DASH							Nov./ Dec. '83
file copy (30,000 bytes, 1 iteration)							
512 bytes per read	18	15	8	6	3	3.00	
1,024 bytes per read	16	11	8	6	3	2.67	
8,192 bytes per read	15	9	8	4	3	3.75	
PRIME NUMBER SIEVE (10 iterations)	11	11	11	4	4	2.75	Nov./ Dec. '83
DRAW THE HAT	643	—	—	223	—	2.88	July/ Aug. '83

pass, take advantage of the fact that DOS 3.0 may be smarter than DOS 2.0 about finding sectors already cached in memory.

CPU-intensive tests, such as the first four Pentathlon benchmarks and the Prime Number Sieve, also realize a two- to threefold improvement in performance. This is due, of course, to the speed with which the 80286 chip can execute instructions. Note that all of these tests use 8088 instructions; none of the source has been rewritten to take advantage of possible optimization using the extended instruction set of the 80286 processor (for example, PUSHA/POPA).

TABLE 2: *Disk Parameter Table*

	360KB FLOPPY	1200KB FLOPPY
rotation speed (rpm)	300	360
tracks/inch	48	96
number of tracks	40	160
head settle (ms)	15	18
track-to-track seek (ms)	6	3
interleave factor	1	1
sectors/track	9	15
cluster size	2	1
data transfer rate	250 Kbits/sec	500 Kbits/sec
	10MB FIXED DISK	**20MB FIXED DISK**
rotation speed (rpm)	3600	3573
tracks/inch	345	750
number of tracks	1224	2455
head settle (ms)	15	12
track-to-track seek (ms)	3	2
interleave factor	6	3
sectors/track	17	17
cluster size	8	4
data transfer rate	5 Mbits/sec	5 Mbits/sec

TABLE 3: *PC/AT Fixed-disk Performance*

MACHINE	PC/XT				PC/AT		
DISK TYPE / DISK SIZE	Floppy 360KB		Fixed 10MB		Floppy 360KB	Floppy 1.2MB	Fixed 20MB
NO. OF SECTORS	708		20672	20688	708	2371	41620
PC-DOS VERSION	2.0	3.0	2.0	3.0	3.0	3.0	3.0
SEQUENTIAL READ							
1 sector	.201	.212	.022	.025	.033	.170	.003
8 sectors	.357	.376	.071	.071	.187	.250	.027
16 sectors	.533	.555	.129	.126	.365	.338	.052
24 sectors	.673	.721	.187	.187	.547	.409	.077
RANDOM READ							
1 sector							
0.10*	.110	.110	.078	.077	.113	.089	.044
0.33	.210	.212	.111	.111	.213	.173	.044
0.50	.235	.310	.146	.146	.217	.173	.054
0.90	.310	.411	.221	.223	.313	.342	0.69
8 sectors							
0.10*	.291	.291	.124	.124	.294	.135	.063
0.33	.390	.401	.165	.165	.393	.217	.069
0.50	.412	.492	.190	.190	.393	.302	.074
0.90	.489	.591	.275	.272	.495	.385	.091

* Seek distance—the distance the heads traveled as a fraction of the width of the disk platter.

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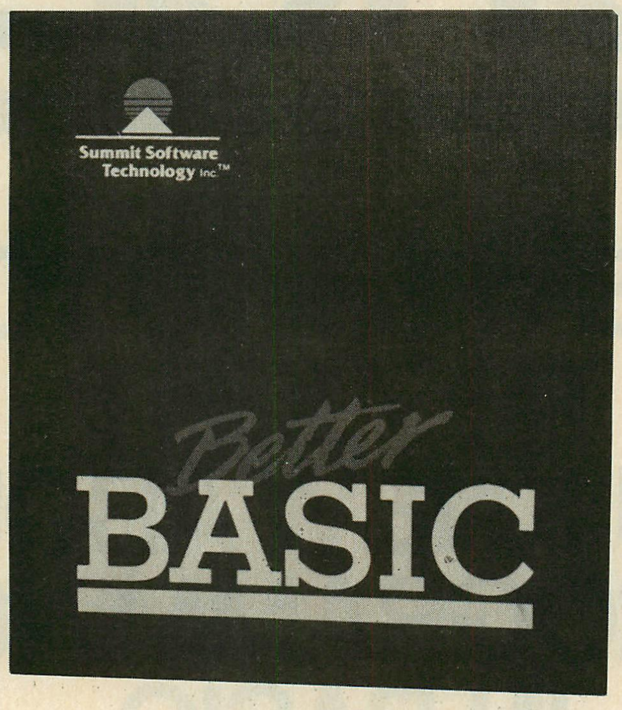

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Byte Magazine

XENIX LIVES

XENIX compared to UNIX System III

AUGIE HANSEN

When IBM went to Interactive Systems for its port of UNIX System III (PC/IX) for the PC/XT, many industry analysts assumed that Microsoft had been nudged out of its preeminent position in the IBM fold of system software suppliers. Not so. Microsoft XENIX lives and is playing on an AT at a computer store near you.

XENIX is also a port of UNIX System III, enhanced with a sprinkling of Berkeley programs as well as some of Microsoft's own additions. The following is a comparison of XENIX to System III, showing what has been left out of XENIX and what goodies have been put in.

THE PRICE OF ADMISSION

XENIX is not for those with a lack of determination and a thin wallet. The minimum hardware configuration is a PC/AT with a half-megabyte of primary storage, 1.2-megabyte diskette drive, 20-megabyte fixed- (hard-) disk drive, serial/parallel adapter, and one or more display systems. The software supports both color and monochrome displays either separately or simultaneously, but the color monitor is supported only in the text mode.

XENIX software is available in three modules: the base operating system (called the kernel), which may be purchased by itself, and two specialized modules for program development and text processing. Basic text editing programs are built into the base system, but document formatting programs for use with various printers and typesetters are packaged separately.

Unlike PC-DOS, which even for new users is essentially a plug-in-and-go operation, XENIX requires a lot of set-up and customization.

THE FAMILY TREE

Just as / is the root of the UNIX file system, The Seventh Edition can be considered the root of the commercial family of UNIX systems. From it can be traced the University of California at Berkeley systems, BSD 4.1 and 4.2 (BSD Berkeley Standard Distribution), and the newer versions produced by AT&T, called System III, and now System V, Release 2. Although the same underlying philosophy pervades all the versions in general use, there are differences among them, some subtle, some not so subtle.

While AT&T is promoting System V as the UNIX standard, IBM is leaning heavily on the older and more established System III. This

Augie Hansen owns Omniware, a Denver-based software development company. He is a contributing editor and writes frequently about communications products.

discussion uses System III as the reference for comparisons.

COMPARISON TO UNIX SYSTEM III

This version of XENIX is a faithful implementation of UNIX System III, although left out—as they should be—are some commands and capabilities associated with UNIX equipped to run on larger host machines like a DEC VAX.

If all three modules are purchased, XENIX is a complete and attractive operating environment for up to three simultaneous users. One user operates from the "console" (the PC's keyboard and display), while the other two users access the system via external terminals connected to serial adapter ports. Table 1 summarizes the major commands by module. Commands that are marked with a # are imports from Berkeley UNIX, and those that are marked with a * are Microsoft/IBM additions.

Operating System. This module is the minimum XENIX configuration for the PC/AT. It is composed of the kernel, a variety of "shells," and commands for user access, file manipulation, communications, accounting, and PC-DOS access. Table 1 lists some of the commands.

Software Development. Programming support is extensive. Compilers for C and FORTRAN (ratfor) are provided along with a complete software Source Code Control System (SCCS), an assembler that produces machine language code for the 8086/88 and 80286 processors, and a full set of utility programs. Table 2 shows commands for the program development environment.

Text Formatting. For converting text source files into finished documents, XENIX provides the following commands and macro packages in the text formatting module:

eqn mm nroff tbl troff

Both nroff and troff are derivations of an earlier document formatter called "run-off," hence the "roff" part of their names. The nroff program produces documents on a wide range of printers and troff works with phototypesetters. The memorandum macros (mm) take much of the drudgery out of document preparation by prepackaging frequently used command sequences. The eqn and tbl commands process text files containing equations and tables respectively.

WHAT'S NEW?

In addition to blazing speed relative to its predecessors, the 80286 microprocessor offers memory protection. XENIX supports Protected mode, which prevents users from interfering with each other's workspaces or the operating system. This is a significant improvement over UNIX systems running on unprotected 8086/88-based machines, which can be easily locked up by a "wild" pointer in a C program.

A visual interface called vsh provides an optional menu-oriented shell for casual users who prefer to point and need only a subset of XENIX commands. It is not the same shell as the Berkeley vsh available on many BSD and AT&T UNIX systems. Vsh can be modified to suit special applications, and it has a flexible, help feature that may also be customized. The Bourne Shell and the C-shell are offered.

The popular vi full-screen editor, the "California" or "C" Shell (csh), and the more command have been imported from Berkeley UNIX. Shell scripts written for csh are not fully compatible with the standard Bourne shell (sh) because of syntax differences. Both sh and csh are command interpreters and powerful, full programming languages.

A new command called micnet allows PCs to be connected in a small network using their serial interfaces. This feature complements the capabilities provided by the uucp and uux commands for large-scale interconnections among UNIX-based computers.

As with PC/IX and PC-DOS, XENIX can coexist with other operating systems on the same hard disk(s). A set of DOS disk file interface commands permits access to files on DOS-format diskettes, but there is no provision to run DOS applications under XENIX.

TABLE 1: *Available Commands for User Access*

getty	login	dd	ed	vi#
at	cron	csh#	sh	vsh#
acctcom	ps	calendar	mail	news
micnet*	banner	dc	diff	grep
sort	uniq	wc	doscat*	doscp*
dosdir*	dosls*	dosrm*	dosmkdir*	dosrmdir*

TABLE 2: *Commands for the Program Development Environment*

adb	ar	bc	cref	ld
lorder	make	nm	prof	strip
admin	delta	get	rmdel	sact
sccsdiff	cb	cc	lint	mkstr#
stackuse*	strings*	xref	lex	m4
yacc	as	awk	ratfor	

IBM Personal Computer XENIX
IBM
P.O. Box 1328-S
Boca Raton, FL 33432
Availability: First quarter 1985
Operating System: $395
Software Development System: $455
Text Formatting System: $145
Total: $995

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PC/Professional Finance Program II .. 149.
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THE WORD *(KJV Bible - 7 disks)* ... 145.
Digital Research
CP/M-86 ... 39.
Dr. LOGO *(requires 192k & RGB monitor)* 69.
Financier
Financier II ... 115.
Financier Tax Series ... 97.
Funk Software
Sideways ... 45.
Harvard Software
Harvard Project Manager ... 219.
Hayes
Please ... 239.
Get free mailing list template for a limited time - also get a second template of your choice free from Hayes.
Koala
Speed Key ... see special
Lifetree
Volkswriter Deluxe *(with TextMerge)* ... 165.
Living Videotext
ThinkTank ... 109.
Lotus Development
1-2-3 *(version 1A)* ... call
Symphony ... call
Micro Education (MECA)
Managing Your Money ... 129.
Micropro
WordStar & Propak come with quick lesson CAI training disk and tutorial disk
WordStar 3.3 ... 219.
Propak *(WordStar/MailMerge/CorrectStar/StarIndex)* ... 279.
Microrim
R:base 4000 ... 269.
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Microsoft
Multiplan *(version 1.2)* ... 125.
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PC Connection Software Special
through November 30, 1984

KOALA TECHNOLOGIES
Speed Key
If you own a Koala Pad you can "upgrade" it to the Speed Key System with this software package — and learn how to take shortcuts through the obstacle courses in many business software programs (see Hardware Special for specifications).

- REQUIRES: Koala Pad or KT 2010 Touch Tablet, game port
- INCLUDES: Software, overlays, manual

... $55.

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PeachPak Series 4 (G/L, A/R, A/P) ... $189.
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Norton Utilities ... 49.
Rosesoft
Prokey 3.0 ... 89.
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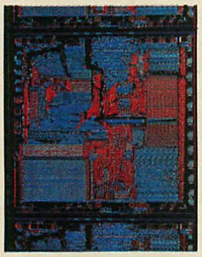

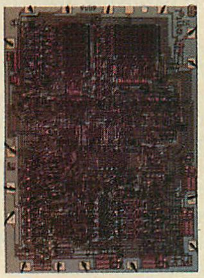

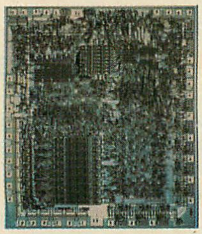

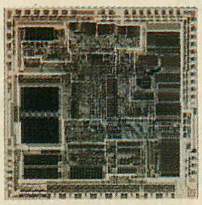

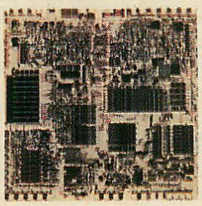

The Evolution of the iAPX 286

Intel's microprocessor answers the high-performance, multitasking demands of a new generation of software users.

BOB GREENE

The iAPX 286, the most powerful microprocessor in the Intel iAPX series, was designed for high-performance applications. It incorporates advanced features that make it particularly suited for task management applications, such as networking and print spooling.

In all of these classes of applications, task isolation is imperative. Facilities for memory management and support for virtual memory (to alleviate the "not enough memory" problem) are also required to build efficient, economical systems. The 286 provides on-chip memory management and protection as well as direct support for task switching. In many cases, the architectural features that the 286 provides in a monolithic silicon chip exceed those of available minicomputers.

The iAPX 286 was designed with two modes of operation: Real Address Mode and Protected Virtual Address Mode. These two modes provide a bridge between software written for the iAPX 8086/88 and the iAPX 286. In Real Address Mode, many of the advanced architectural features of the 286 are not available. Instead, this mode emulates a very high performance iAPX 8086 (as will be explained later). The degree of compatibility is such that programs stored in Read Only Memory (ROM) for use with an 8086 can be executed directly.

In Protected Virtual Address Mode, a more powerful superset of instructions for task management, virtual memory management, and

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protection becomes available, making the iAPX 286 ideally suited for multitasking, multi-user applications. The additional instructions that become available in this mode relate to the manipulation of those features; the base instruction set is identical to the 188/86 and a superset of the 8086 set. In this mode of operation, compatibility with the other members of the family is still maintained: most programs can be recompiled or reassembled and executed on the 286 in Protected Virtual Address Mode.

APPLICATIONS EVOLUTION

Due to the limitations of 64KB addressing, the earliest applications of microprocessors were confined to appliance control, executed from programs in ROM. Most of the programming was done in assembly language. High-level languages were just beginning to develop.

As the applications evolved, two problems were noted by programmers. First, the address space of 64KB was too small for some of the applications that were emerging, and second, as these processors became ubiquitous, a need developed for languages that would be easier to program and maintain. The industry responded with a second generation of processors tailored for high-level languages. This generation was characterized by a larger address space; in some cases, direct support for high-level languages was built into the chip.

The new microprocessors gained widespread popularity and were in part responsible for the creation of machines like the IBM PC. Many users began to want to network their computers and streamline processing. One key to system efficiency is providing resource sharing for printers and large mass storage devices, and allowing individuals in a common environment to share programs and data. Again, the industry responded to the demand with a third generation of machines that were optimized for this new world of multitasking applications (see figure 1).

The third generation of machines had some architectural restrictions; because the investment in the existing software base was so large (about $4 billion for the IBM PC, according to many industry watchdogs), compatibility to the previous generation absolutely had to be maintained.

The response of Intel and other manufacturers was to develop a new generation of chips, compatible with the previous generation and its software, but that incorporated the advanced features necessary to support the requirements of the new generation of users. These features included performance, virtual memory support, multitasking support and protection.

Some chip manufacturers have incorporated a wider bit path onto their chips, arguing that 32 bits will handle all of the requirements. But, expanding the processing bandwidth is only one way to increase performance and does so only at the laboratory benchmark level. Real processing improvement is realized at the system level, such as in a task switch or in a parameter exchange between two protected environments.

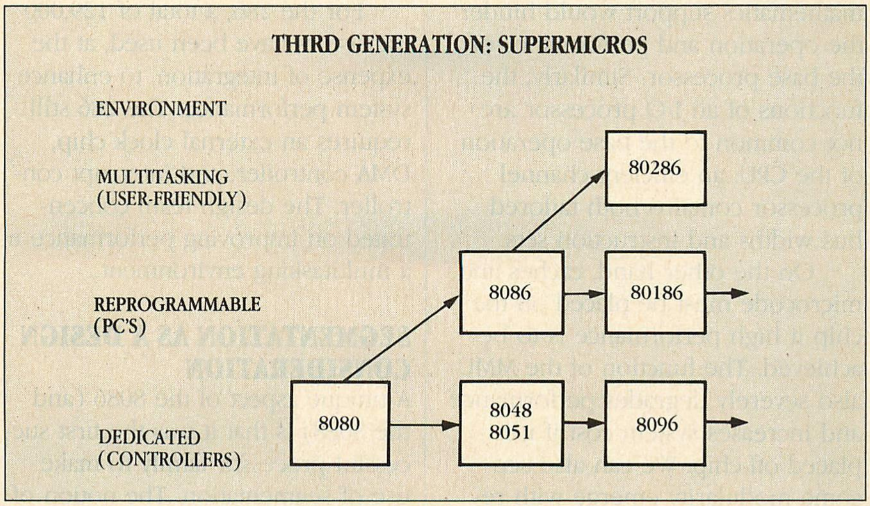
Intel's approach is first to tackle the important parameters of performance, virtual memory support, and multitasking support, including protection, and then to increase the processing bandwidth to 32 bits. This preserves compatibility, but still addresses the critical requirements for a high performance computer. Intel will provide upward compatibility to the 32-bit level after the important system performance areas have been addressed.

ELEMENTS OF PERFORMANCE

The applications evolution described above discussed the changing nature of applications and implied the need for additional performance. When chip designers look at the palette of available techniques to improve performance, several possibilities are available.

The data bus width can be increased, thereby increasing the bandwidth of the machine internally, externally, or both. Internally, pipelining (or parallelism) can be used to increase internal performance. The use of caching directly on the chip can dramatically reduce delays between requests for data, code, or stack information, without requiring the addition of expensive (high-speed) memory, local to the chip.

FIGURE 1: *Microprocessor Evolution*



Externally, the interleaving, or multiplexing, of addresses and data on the external bus (that is, any path leading to memory), can have a dramatic negative impact on the throughput of memory subsystems. For this reason, the multiplexed (address and data) bus of the 8086 was replaced with a higher performance demultiplexed bus to support the system requirements of third generation applications.

Perhaps the most significant contribution to system performance can be made by incorporating direct support for the application into the silicon itself. The other enhancements described above will further improve performance.

FUNCTIONAL PARTITIONING

Functional partitioning was first used in early, large mainframe computers. As VLSI technology matured, systems architecture had to be constantly reevaluated, because the new form factor allowed new levels of integration. This posed new problems for chip designers: Where are the lines drawn? Should a cache be on- or off-chip? What about the microcode? What about the required functions for a math coprocessor, or for a memory management unit (MMU)?

Certain functions should be integral to the chip; others need not be. Inclusion of necessary 80-bit registers for IEEE floating-point mathematics support would hinder the operation and performance of the base processor. Similarly, the functions of an I/O processor are not common to the base operation of the CPU: an efficient channel processor contains both tailored bus widths and instruction sets.

On the other hand, caches and microcode must be placed on the chip if high performance is to be achieved. The function of the MMU also severely degrades performance and increases system cost if it is placed off-chip. We can also see some modularity emerge with respect to chip design in that not all users require floating-point processing or I/O processing, but most want high integrity and high performance with maximum cost-effectiveness. By adopting a well-partitioned architecture, the benefit of modularity can be passed on to the end user. Not all factors of partitioning are driven by technology and design teams. System performance and cost can weigh equally with technological considerations.

If the semiconductor industry can accommodate large numbers of transistors on a single, manufacturable die, then possible uses for those transistors must be examined. In the case of the 8086, few functions other than the necessary ones could be performed with the limits of 2.5 micron geometry, but with the arrival of HMOS II, Intel's second generation high-performance metal oxide semiconductor process, new dimensions were opened.

In the case of the 186, these transistors were spent to provide a higher level of integration. Approximately 22 separate devices (clock chip, DMA controller, timer counter, interrupt controller, chip select decode logic, bus controller) have been included on the chip along with the CPU, although the architecture is identical to that of the 8086. The higher level of integration is used only to provide a more cost-effective chip for system designers.

For the 286, a total of 129,000 transistors have been used, at the expense of integration, to enhance system performance. The 286 still requires an external clock chip, DMA controller, and interrupt controller. The design team concentrated on improving performance in a multitasking environment.

SEGMENTATION AS A DESIGN CONSIDERATION

A unique aspect of the 8086 (and the 8088) is that it was the first successful processor family to make use of segmentation. The notion of segmentation is not unique to Intel, having been used quite early on in mainframes such as the Burroughs B-200; however, its application in a silicon architecture is unique.

The approach was directly in line with the goal of optimizing the architecture for use with high-level languages. The 8086 has four segments available to any applications program: one each for code, data, and stack, and one extra. In the development of the architecture, four segments were not absolutely necessary, but three is not exactly a "nice" binary number.

In addition, some of the registers in the machine were dedicated implicitly to work with these segments. While at first glance, the implicit selection of registers may appear to be a limitation, experience shows that it saves substantial amounts of code at the machine level. Implicit selection makes it unnecessary to write or use the subroutine that says, "This-time-I-want-to-use-general-purpose-register-'X'-for-my-code, general-purpose-register-'Y'-for-my-data, etc."

When working with a 16-bit machine, there is a natural division of the memory space into 64KB areas. (Remember that 16 address bits corresponds to 64KB of address space.) In anticipation of the need for data spaces larger than 64KB, a special instruction was provided to "speed up" access to additional data segments. The addressing scheme of the segmented 8086 is quite simple. A value can be placed directly in the segment register or a segment can be implicitly determined by the programmer/compiler's choice of register, or the segment override prefix can be used to alter the chosen register's implicit function. The 16-bit value in the segment register is then shifted left by four bits, resulting in a 20-bit segment address field. This method of addressing imposes "paragraphs," forcing segments to begin on a 16-byte boundary.

The concept of segmentation has been extended to the 286; the motivation for doing it in this manner involves several factors.

First, the 286 must use segments as its fundamental model in order to be compatible with the existing base of applications software.

Second, high-performance, multitasking capability requires the direct support for multitasking to be built into the chip. The only logical place to provide protection between the program/programmer visible space and the memory space of the machine is to break the line. This provides the program and programmer with a consistent, compatible view of the machine. With isolation provided in the silicon, the programmer can concentrate on the applications at hand without having to determine what protection policy he wants to use.

In providing this isolation, Intel has addressed two other important facilities: task switching and memory management. In contemporary applications and operating systems, it is assumed that the machines will be multitasking, but they also could be thought of as single-user. The machine does not care. At the machine level, a task is a single thread of executable code; although the code may have been loaded by another user, the context of the machine is that of the single task. Each task can run at one of four privilege levels, and its code and data areas are protected from modification by other tasks.

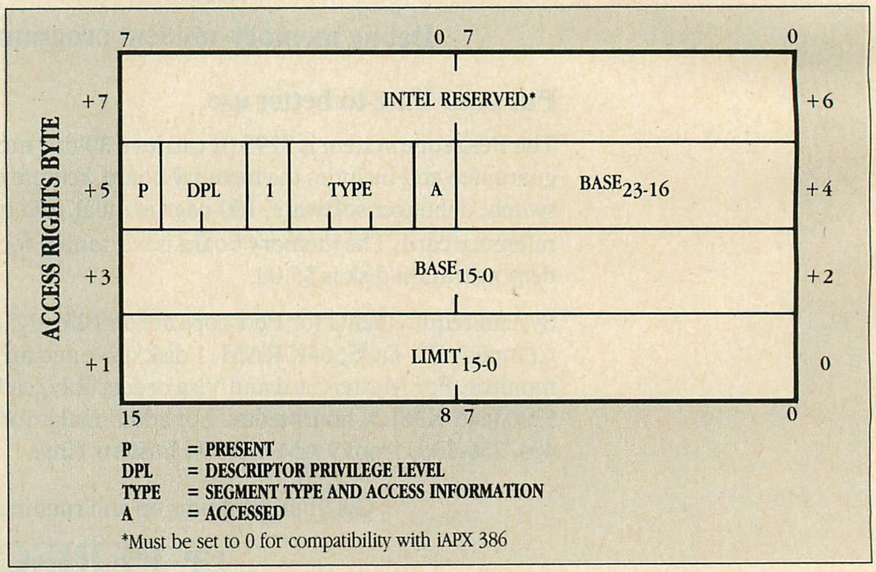
Multitasking implies the notion of a task switch. The content of four descriptors are "cached" on the 286 chip, thus providing very rapid access to the segments associated with a particular task. Caching the context of a particular task on the chip means that in switching to another task, the "on board" descriptors are stored in memory and a new set of four descriptors is loaded. The task switch takes 22 microseconds; this speed greatly reduces the idle time of the processor and dramatically improves overall system performance.

The other important aspect that has been addressed is the inclusion of virtual memory management.

MEMORY MANAGEMENT

Memory management inserts a mapping operation between logical addresses and physical addresses. Memory addresses are viewed by programs as a logical sequence; that

FIGURE 2: *Segment Descriptor*

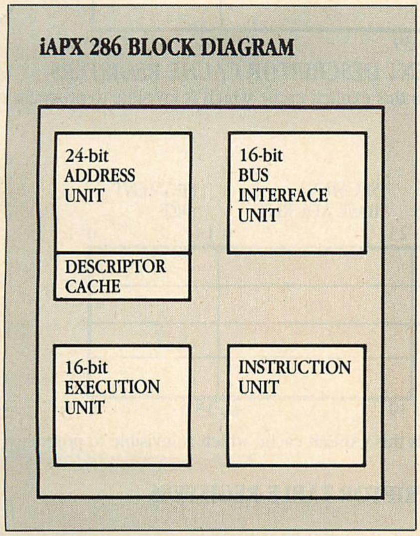


is, they have meaning in the context of the program, but not with respect to the physical addresses in real memory. Because the logical address spaces are independent of physical memory (this is sometimes referred to as dynamic relocation), the mapping or assignment of real address space to virtual address space is transparent to software. This mechanism allows the control of the allocation of space in real memory without regard to the specifics of individual programs.

When operated in Protected Virtual Address Mode, the iAPX 286 provides an efficient on-chip memory management architecture and supports the implementation of virtual memory systems in which chunks of code and data are swapped between real memory (system memory, RAM) and secondary storage (floppy disk, hard disk, bubble) independent of and transparent to the executing programs. Thus, a program-visible address is more correctly called a virtual address than a logical address, because it may refer to a location not currently in real memory.

The motivation for implementation of a virtual memory system is quite straightforward and simple.

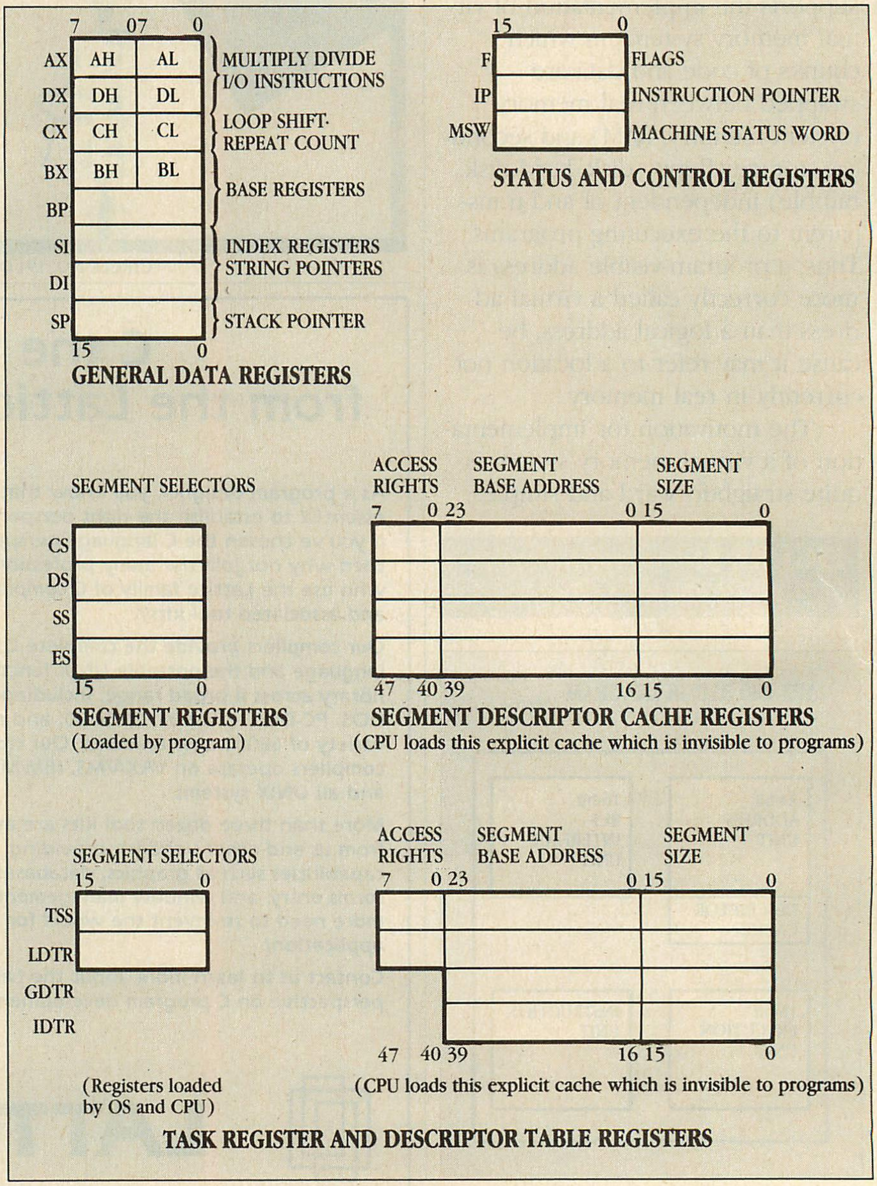
FIGURE 3: *Functional Partitioning in the iAPX 286*



Mass storage devices are and will continue to be less expensive than semiconductor RAM. The current cost ratio between RAM and disk, for example, is about 400:1. From a system cost point of view, it would be desirable to have a "RAMless" system, but users would find such a system unacceptable from a performance standpoint. The popularity of "RAM disks" illustrates this point. On the other hand, because 10MB of system RAM would increase the cost of most systems beyond the threshold of pain for all but the most wealthy, a compromise is made between system RAM and mass storage. In fact, with a virtual management scheme, the size of programs and data can easily exceed the size of physical memory.

In the iAPX 286, memory management is performed as follows: the segment, referenced by the descriptor, can be either present or not present, as indicated by the P bit in the descriptor format (figure 2). If the segment referenced by a particular instruction is not present, an interrupt is generated and the

FIGURE 4: *Full Register Set*



operating system can use this indication to activate its swapping routine to go and get the required segment from the disk, and the instruction can be automatically restarted.

PIPELINING

From a silicon (micro) architecture point of view, pipelining is the use of transistors in parallel. The more transistors that are simultaneously active, the higher the performance will be. Referring to the iAPX 286 block diagram (figure 3), the operation is as follows: the 286 CPU is subdivided into four main parts, each of which carries out part of the entire machine cycle. This division of labor results in a tremendous gain in efficiency. For example, while the Execution Unit is carrying out an instruction, the Bus Interface Unit (BIU) is prefetching from memory the next instructions, which stand ready to be processed by the Instruction Unit.

The BIU conducts all of the interface circuits for interface with the outside world, which means that the address drivers and the data buffers are located there. Also located there are the instruction prefetcher and six-byte code queue. At the 8MB/sec data rate (achieved at 8 MHz processor clock frequency), the high-performance bus interface requires only 243-nanosecond access time memories (unbuffered).

The BIU is capable of generating autonomous bus cycles, responding to the status of the prefetch queue. Before the address is actually output, limit checks are performed on any address to make sure that the target address is within the limit specified by the Limit portion of the descriptor. The BIU also contains the interface for processor extensions (such as the 80287 Math Coprocessor).

The Instruction Unit (IU) prepares and buffers instructions based on information from the BIU; it decodes up to three instructions and stores them in the instruction queue. The instructions are stored in the 69-bit internal instruction format so that additional processing is not required when they are received by the Execution Unit (EU).

The EU contains the Arithmetic Logic Unit (ALU) and the multiply/divide engine, including a 1,536-word by 35-bit control ROM and a 22-word by 16-bit register file. As an example of its speed, the EU can perform logical arithmetic operations on two registers in 250 ns.

The Address Unit (AU) contains the descriptor cache (four-word by 48-bit) and performs all of the necessary address access rights and type checking, as well as the effective address calculations.

The Memory Management Unit

could be partitioned on-chip (as in the 286) or off-chip as in traditional architecture, but the off-chip approach has two problems.

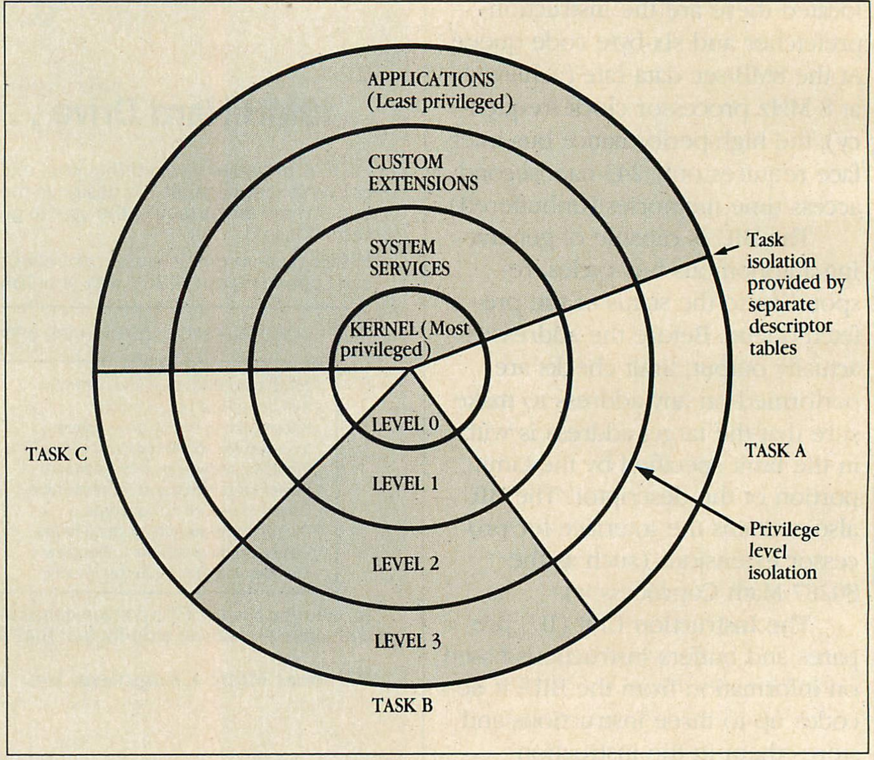
The first of these problems relates directly to system cost. In order to maintain the processor at full performance, the delay between "addresses out" and "data in" needs to be minimized. An external MMU lives directly in this path, contributing approximately 100 to 150 ns of delay. At the system level, the delay of the required buffering, chip select decoding, and the refresh arbitration for dynamic RAMs needs to be added as well. The system designer is then faced with an awkward decision of using wait states, which slow down the processor, or using expensive high-speed (possibly ECL technology) memories. The 286 will run with 0 wait states with unbuffered memories at an access time of 243 ns.

In order to temper the design with reality, most iAPX 286-based systems use 120-ns DRAMs, which are readily available and cost-effective. These DRAMs, when used with the Intel 8207 dynamic RAM controller, allow operation with 0 wait states. The difference in access time between the 243 ns stated above and this speed of 120 ns allows the dynamic RAM controller to arbitrate between memory access cycles and memory refresh cycles.

The second problem with an off-chip MMU is more subtle. The MMU provides the translation from a virtual address to a physical address. When the processor has calculated and verified a virtual address, that address is then passed to the MMU for translation, a process that can take 100 to 150 ns, as described above.

While the translation is taking place, the processor starts to process the next instruction, and then a page-(segment)-not-present interrupt occurs from the MMU. The processor has no choice, the current instruction must be aborted, an operating system call generated to

FIGURE 5: *Four Privilege Levels*



invoke the swapper, and, after the desired segment (page) is swapped in, the aborted instruction reissued.

With an on-chip MMU, restartable instructions are easily supported. The Address Unit is checking the target address while the instruction is still in the instruction unit, so if a fault (present bit in the descriptor = false) is detected, the operating system call can be issued and the instruction restarted because it was never really aborted.

iAPX 286 OVERVIEW

The 286 block diagram consists of four actual units, with a fifth unit implied by way of cooperation among the other four. It has two modes of operation, Real Address Mode (8086 mode) and Protected Virtual Address Mode (286 mode). The 286 always wakes up in 8086 mode; after a power-on reset, the 286 is initialized to the Real Address Mode. In Real Address Mode the total available physical address space is 1MB, while in Protected Mode the physical address space is 16MB (2^{24}), and 1-gigabyte virtual address space (2^{30}). The programmer views this address space as a collection of up to 16KB linear address spaces called segments, each of which can be from 1 byte to 64KB. This differs from the 8086, in which the segment size is fixed at 64KB. Figure 4 shows the complete register set of the 80286.

The mode of operation (Real or Protected) is controlled by the programmer by way of the protection enabled (PE) bit in the machine status word (MSW). Note that the programmer can only set the PE bit; clearing it can be done only by rebooting the computer, causing it to revert to the Real Address Mode. This was done to preserve the integrity of the protection model, saving it from indiscriminate switching between protected and nonprotected modes, which could corrupt the protected code and data.

When in Real Address Mode,

the 286 instruction set is completely compatible with the 8088/86 processors. In addition, new instructions, identical to the iAPX 186/88 processors, are available. When in Protected Mode, there is an additional System Control instruction set is available.

In the iAPX 286, the content of the segment selector points to a descriptor that is cached on the chip. At any point in time, four descriptors are so cached on the chip, one descriptor corresponding to each segment selector. This cached information, when combined with the content of the various general purpose registers, comprises the context of the machine. The context must be saved (and restored) by the operating system during task switching.

The addressing model of the 286 is similar to that used in the 8086, the primary difference being the insertion of the level of isolation provided by the descriptor. In fact, the construct of the 286 address can be thought of as a multiple element value, with the first element being the actual content of the segment selector and the next 64 bits being determined by the descriptor. Of course, the offset is appended to the base of the segment in a separate operation; the descriptor provides the base address, not the intended program location.

Thus, it can easily be seen that the 16-bit value in the segment selector provides a pointer to a location in the larger space represented by the 24 bits of base address. This corresponds to a space of 16MB. The very large virtual space of the iAPX 286 is the result of taking the maximum amount of space in each descriptor table (local descriptor table and global descriptor table), which is 8,192 entries each for a total of 16,384, and multiplying it by the maximum size of each segment (65,536). This results in a total virtual space of 1 gigabyte.

An interesting point about this size is that the upper limit of segment size is determined by the word size of the machine—16 bits can reference 64KB of space. All 16-bit machines have some limitation at the 64KB point; to change this limitation requires changing the word size. Some 16-bit machines claim the ability to address more than 64KB of contiguous space; however, examination of those machines will show that the instruction pointer (IP), not the calculating path within the machine, accommodates more than 16 bits. This means that the ability to address more than 64KB is somewhat restricted in that it must be sequential and within 64KB of the present IP indication. Otherwise, the target address

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of a conditional jump must be calculated using a 16-bit engine.

iAPX 286 DESCRIPTORS

Descriptors are the key to the advanced features of the 286. They make memory management, virtual memory, and protection possible, and, because they are cached on the chip, rapid task switching is possible. The 286 has two classes of descriptors—those for code and data, and those dedicated to system and control mechanism; their operation and construction are essentially the same.

The descriptors contain the "real" location pointed to by the content of the segment selector. The actual descriptor is cached on the chip for rapid access and checking by the Address Unit. The descriptor contains the information about size and location of the referenced segment as well as three other bytes (see figure 2). Two of those bytes are reserved for iAPX 386 compatibility, while the third is used to provide the information about type and access rights.

iAPX 286 TASK SWITCH

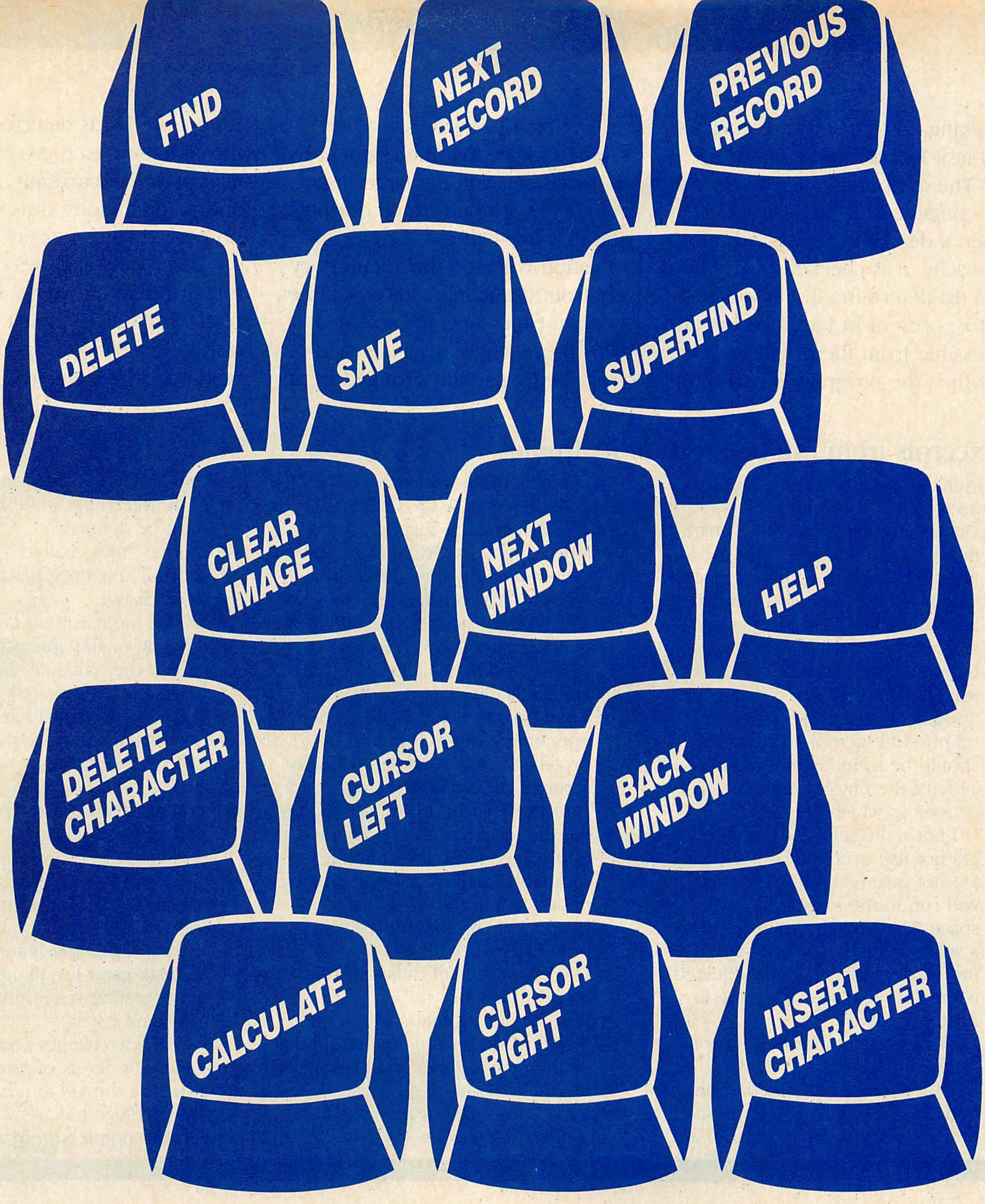
The iAPX 286 caches the content of four descriptors on the chip. Conceptually, the switching of tasks is accomplished by exchanging the content of the on-chip cache with values that are contained in the descriptor table (located in main memory). This operation is carried out automatically, whenever the instruction "change task" is issued (constituted by an intersegment (long) JMP or a CALL to a task state selector (TSS) descriptor.

A task switch may occur in one of four ways: (1) the destination selector of a long JMP or CALL instruction refers to a TSS descriptor; (2) an IRET instruction is executed when the NT (new task) bit in the flag word is set; (3) the destination selector of a long JMP or CALL instruction refers to a task gate; (4) an interrupt occurs. This interrupt's vector refers to a task gate in the interrupt descriptor table.

The TSS is always located in the global descriptor table (GDT), which is the only common area. It must always be available to the operating system. The TSS is a data type that includes the definition of the task—that is, its address space and execution state (active or suspended). Forty-four bytes of information about the task are contained in the TSS, including the contents of all registers and flags, the initial stacks for privilege levels 0-2, the GDT selector, and a link to the TSS of the previously executing task. Each TSS has a single, unique, unambiguous selector, which allows a multitasking operation system to refer to (manipulate) tasks by way of a single pointer.

iAPX 286 PROTECTION

There are three aspects to the protection model of the 286: data type



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checking, system software isolation, and task isolation (see figure 5).

The attributes of each segment are contained in the descriptor. When a descriptor is loaded into the cache, it is checked by the hardware to determine if it is valid—that is, present in real memory and accessible from the privilege level in which the program is currently executing. Checks are also performed to see that the segment type is consistent with the target usage. All checks are performed during the first one-half clock cycle; any violation will stop that memory cycle from occurring and cause an exception (interrupt) to be issued. This prevents the machine state from being partially changed by an exception that is detected part way through a cycle. These checks all take place concurrently with BIU and IU operations, thus incurring no performance penalty.

The available types of descriptors are read-only data segment, read/write data segment, execute-only code segment, and execute/read code segment. The hidden

Excerpts from Intel Compatibility Guide

Summary of Programming Guidelines for all Software Classes:

- Do not rely on processor instruction execution times.
- Keep all data and code references within logical segment boundaries and consistent with the segment's attributes.
- Do not rely on the iAPX 86 relationship between the value in a segment register and the selected physical memory. Programs should be as independent as possible of the physical memory addresses in which they reside.
- Do not write self modifying code.
- Do not use overlapping segments.
- Do not assume two different tasks will run in the same address space. The segment referenced by a selector value in one task may not be the same segment referred to by the same selector value in another task.
- Do not store temporary values in segment registers.
- Do not attempt undefined operations (for example, using the same prefix several times in front of an instruction, undefined opcodes, POP CS, or MOV CS, OPERAND).
- Avoid operations that may be restricted by the iAPX 286 to assure system integrity, low interrupt latency, or low bus request latencies (for example, shift/rotate with shift count greater than 31, locked CMPS/STOS/SCAS/LODS, STI, CLI, HALT AND I/O instructions).
- Write programs independent of operation changes required by protection (for example, XCHG asserting LOCK, different single step priority, POPF and IRET not changing the interrupt enable flag or I/O privilege level, invisible interrupt table, or IRET affected by the nested flag in the flag word).
- Do not rely on the value pushed onto the stack by PUSH SP.
- Use inter-segment calls to invoke an OS function.
- Plan for enhancements to an iAPX 86 OS made possible or required by the new features provided by the iAPX 286.

Source Code changes required for any operating system:

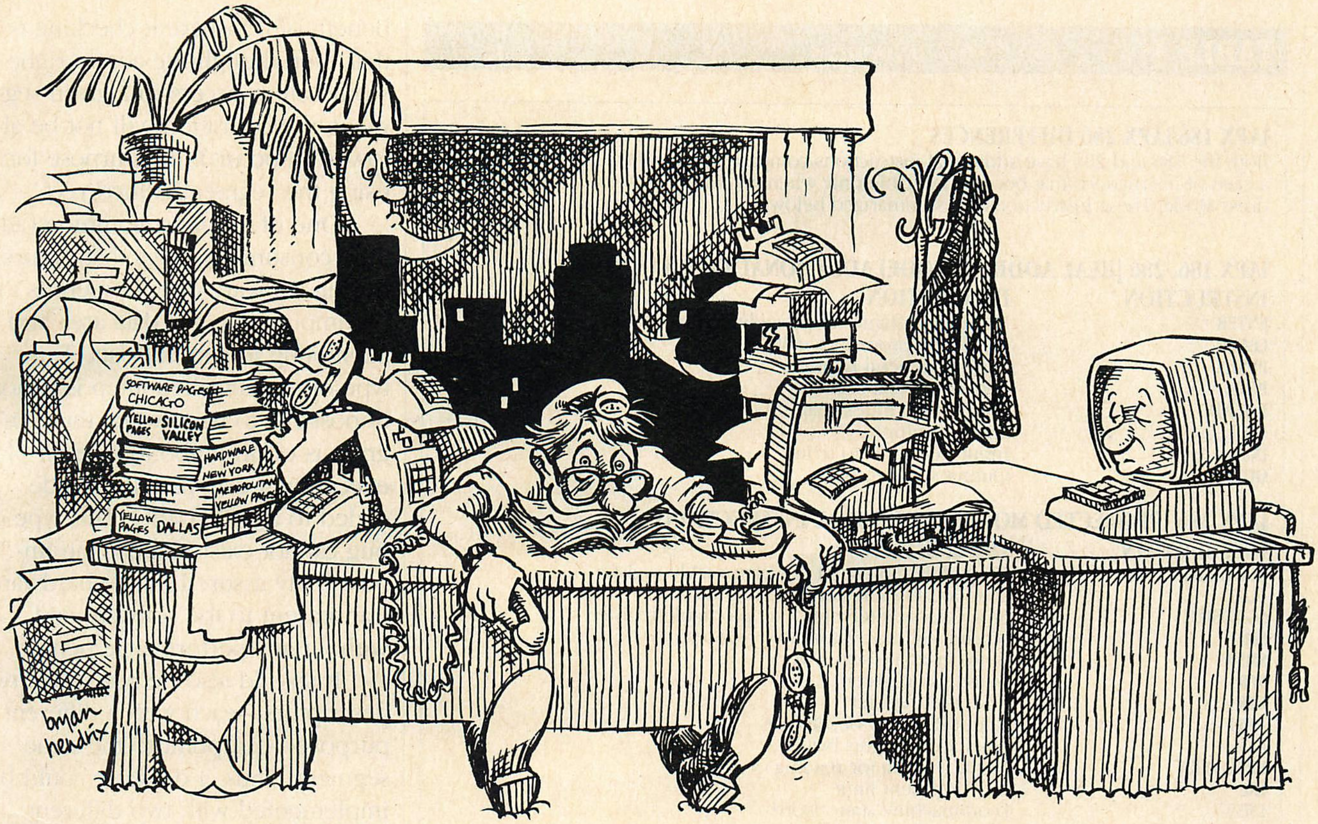
- Initialization code must change.
- More interrupts and exceptions must be defined.
- Loaders must change.
- Dynamic memory allocation code must change.
- To use the hardware task switch function or multiple address spaces, the scheduler must change.
- Code that accesses task context (e.g., register state) must change.
- Code which accesses the interrupt table must change.

Source code changes required for operating systems with task isolation:

- Add pointer validation code to the prologue of procedures is expecting pointers from less trusted callers.
- Add code to manage shared resources and prevent inadvertent sharing if previously freed.
- Add call gates for all entries into the operating system that are seen by the user.

Source Code changes required to use multiple levels of privilege:

- Structure the OS to use the iAPX 286 privilege hierarchy.
- Validate pointers from all callers.



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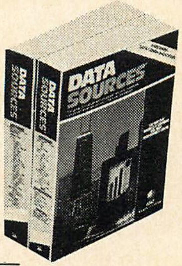

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TABLE 1: *iAPX 186/286 Differences*

iAPX 186/iAPX 286 DIFFERENCES

Both the 186 and 286 have additional instructions compared to the 8086. The 286 also has a class of instructions that become available only when it is in the Protected Virtual Address Mode. These instructions are summarized below.

iAPX 186, 286 [REAL ADDRESS MODE] ADDITIONAL INSTRUCTIONS

INSTRUCTION	DESCRIPTION
ENTER	Make stake frame for procedure parameters
LEAVE	High-level procedure exit
PUSHA	Push all general registers
POPA	Pop all general registers
BOUND	Check array index against bounds
IMUL	Signed multiply
INS	Input from port to string
OUTS	Output string to port

iAPX 286 [PROTECTED MODE] ADDITIONAL INSTRUCTIONS

INSTRUCTION	DESCRIPTION
LGDT/LIDT	Load global/interrupt descriptor table register
LLDT	Load local descriptor table register
SGDT/SIDT	Store global/interrupt descriptor table register
SLDT	Store local descriptor table register
SMSW	Store machine status word
STR	Store task register
LTR	Load task register
ARPL	Adjust RPL field of selector
LAR	Load access rights byte
VERR/VERW	Verify a string for reading or writing
LSL	Load segment limit
LMSW	Load machine status word
CTS	Clear task-switched flag

benefit of transparent checking is that even though the access rights would allow access to a given segment, the operation will not be allowed to occur if the purpose for using the segment is incorrect.

One of the most common (and time-consuming) bugs that occurs during software development is that of jumping into the data area and attempting to execute data. This type of uncontrolled jump is almost impossible to trace when the program is off in limbo as a result of executing a data pattern that decoded to a JMP LIMBO. This type of bug cannot exist in a 286, an impossibility assured by the hardware, transparent to the software and without any performance penalty.

It should also be noted that two descriptors—each with a different purpose—can point to the same segment. Thus, a database could be implemented with two different tasks accessing it: one for use (read only, e.g., an invoice generating program) and the other for creation/maintenance (read/write, e.g., an order entry program).

The protection model provided by the segment/descriptor-based architecture will withstand both inadvertent and malicious attempts to access or modify code or data not in the domain of a given task. First, complete task integrity is assured by the descriptors. It is impossible to access an address that is outside the location and limits specified by the descriptors.

Second, descriptors can be created or modified only by instructions available at privilege level 0. Third, a given segment can be accessed only for the correct purpose.

FAMILY COMPATIBILITY

As many people start to use and program with the iAPX 286 as designed for the IBM PC/AT, many questions will arise with respect to compatibility. Every effort has been made on the part of Intel either to assure compatibility at the binary

level or to document exceptions. Most problems with compatibility are the result of software or hardware developers relying on undocumented instructions or features, or not following published system level (BIOS or DOS) interfaces.

Excerpts from Intel's compatibility guide are quoted in the accompanying sidebar, which outline the exact details of compatibility. In addition, strict attention should be paid to the software/hardware interface, particularly if one is attempting the software design of programs to run on any version of the IBM PC. The instruction sets of both the 8088 and the 80286 are published and well-documented. The differences between the two instruction sets are shown in table 1. I would emphasize that under no circumstances should undefined opcodes be used in either processor. Using these opcodes means relying on untested features that may not be present in future versions of the respective processor or that may perform a different function in future generations of the iAPX family. With respect to PC compatibility, IBM has thoroughly documented the DOS interface. Any program that makes calls directly to the BIOS or, worse yet, directly to the system resources is almost certain to be incompatible with either later versions and permutations of the IBM PC family or non-IBM implementations of compatible machines.

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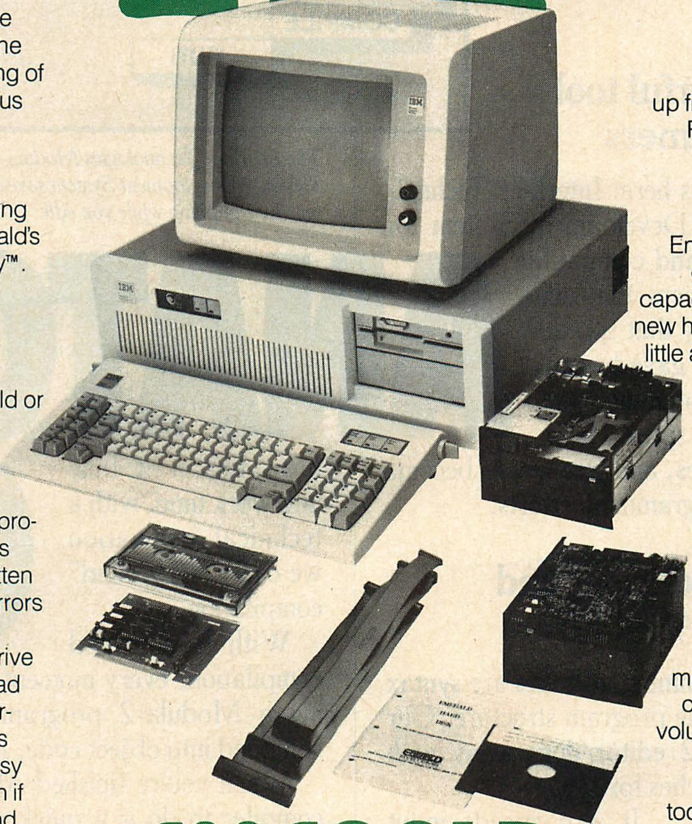

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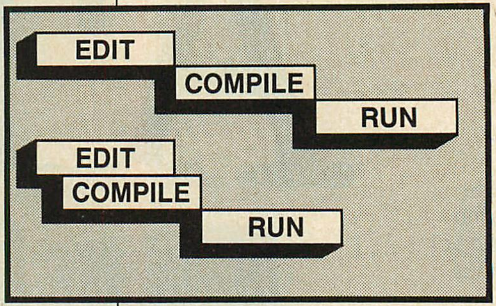

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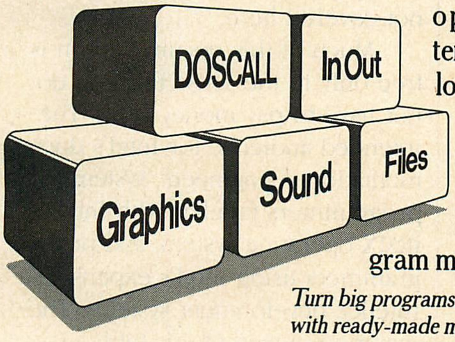

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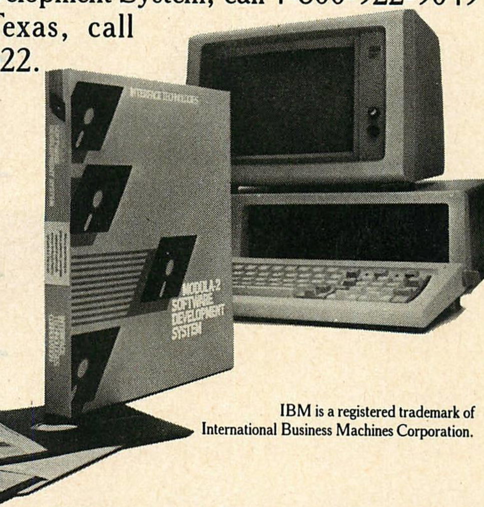

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An Intel Bibliography for iAPX 286

An annotated guide to Intel literature on the 80186, 80286, and the 8089

JAMES CREANE

The IBM PC/AT has considerable latitude and capacity for future hardware expansion, but information about the machine, its operating system and its architecture is, as is always true at the beginning of the life cycle of any computer or computer chip, scarce.

The only current source of information about hardware expansion is from the Intel Corporation, manufacturer of the PC/AT's iAPX 286 processor. Authoritative books usually arrive long after the initial critical demand has passed.

I mention this for two reasons. Intel's literature is not applications-oriented. Source code examples are oriented toward Intel hardware, systems software, and iRMX, and translations are left to the reader. Second, the 80286 introduces concepts that may be central to programmers for minicomputer and mainframe operating systems, but unfamiliar to microcomputer programmers.

This bibliography begins with the 80186 because the additions to its instruction set (also found on the 80286) are likely to be available in systems software before 80286 systems software appears. Also, I am including the 8089 despite its lack of market adoption. As demands from attached peripherals increase, the need for a chip like the 8089 will increase as well to conserve clock cycles on the CPU. Dedicated I/O processors are common on mini and mainframe computers. Expanded microcomputers will soon need them as well. The 8089 works with the 80186; an 80289 has not yet been announced. Finally, Intel has many other new or undiscovered products, such as the 8274 multiprotocol communication chip not covered here.

Much of this documentation is free only in the sense that you do not have to pay money for it. The intended audience for Intel's documentation is engineers, systems programmers familiar with Intel's iRMX operating system, and programmers using Intel's expensive Intellec development systems. The major advantage of this bibliography is that Intel has agreed to ship this literature to outsiders. A maximum of five free items per order is allowed. I suggest you make the *Literature Guide* one of the five because it lists Intel's worldwide sales and technical support offices, some of which stock the literature.

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James Creane is a software consultant who lives and works in New York City.

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THE 80186

"16-Bit Microprocessor Crams Peripheral Support on a Chip." Order Number: 210601.

"iAPX186: The First 16-Bit CPU Board on a Chip." Order Number: 210488-001. I suggest this brochure and the one above as an introduction for general users.

"iAPX 86/50, 186/50 CP/M-86 Operating System Processors." Order Number: 210705-001.

"How To Select a VLSI Operating System." Order Number: 210341-001. The 80150-2 is part of an ongoing effort to put operating system kernels into silicon. The VLSI pamphlet compares various microcomputer operating systems including iRMX-86.

"iAPX 186,286 Benchmark Report." Order Number: 210826.

"iAPX 186 High Integration 16-Bit Microprocessor." Order Number: 210451-003.

"iAPX 188 High Integration 8-Bit Microprocessor." Order Number: 210706-002. This pamphlet and the one above (about 50 pages) contain the instruction set and an overview of the hardware.

"ASM86 Macro Assembler Pocket Reference." $3.50. Order Number: 121674-002. A handy, spiral-bound edition of the instruction set for the 8086/87, and 80186. Useful for assembly language programmers.

"8086/8088/8087/80186/80188 Programmer's Pocket Reference Guide." Order Number: 231017-001. Has 10 pages on the 8087 not available in the previous item, but a little less detailed about the 80186. Stapled rather than spiral bound. Otherwise, it is the same as the above item.

iAPX 86/88, 186/188 User's Manual-Programmer's Reference, $16.95. Order Number: 210911. (Available from Reston Publishing Co.) An essential document for the 8086, 8087, 8089, 80186/88, and 80150 for programmers and hardware designers.

THE 80286

"iAPX286: Advanced Solutions for Your New Products." No order number. A sales brochure listing essential features.

"Integrating Memory Management Into the CPU." Order Number: 210308-001. A more technical overview than the previous entry.

"Integrating Memory Management Into the CPU." Order Number: 210840-001. An introduction to memory management and multitasking.

"Memory Protection Moves Onto 16-Bit Microprocessor Chip." Order Number: 210399-001. An introduction to memory management and multitasking.

"iAPX 286/10 High Performance Microprocessor With Memory Management and Protection." Order Number: 210253-004.

"80287 80-Bit HMOS Numeric Processor Extension." Order Number: 210920-002.

80287 Support Library Reference Manual, Rev. 1, $23. Order Number: 122129. Very useful for early development work on the 80287, but the information is given for Intel's systems software and hardware. Much of the information in this reference is about the software emulation package Intel provides for the 80287.

"82284 Clock Generator and Ready Interface for iAPX 286 Processors." Order Number: 210453-001. This contains the instruction set for the 286 only.

"82288 Bus Controller for iAPX 286 Processors." Order Number: 210471-001.

"ASM286 Assembly Language Pocket Reference." Order Number: 121926-001.

ASM-286 Assembler Language Reference Manual, Rev. 1, $42. Order Number: 121924. Useful information for software developers who own an Intellec development system, or who want sample assembly language code.

iAPX 286 Hardware Reference Manual, $15. Order Number: 210760-001. Written for system designers, hardware engineers, and OEMs, this book has other important users. For software designers, it provides important insights into the overall architecture of the chips. Important information is provided about 286 specific aspects such as local, system, and dual-port memory. Additionally, memory

is covered in terms of I/O subsystems, the bus interface, interrupt handling, and other aspects of system integration. Other chips needed for system integration, such as the 80284, 80288, 8282, and the 8287 are, of course, introduced and explained. This book and the next two form a trilogy. Some duplication of material occurs, but it is presented from different viewpoints. So, if you are a programmer, you may obtain only a vague sense of what is going on if it is presented from the hardware point of view. But your initial understanding will have prepared you well enough for when you get to the other books in the trilogy. I suggest you get all three if you can afford to; I have indicated other choices if you can not. Intel uses the Multibus for its machines since it has the speed and bandwidth for complex operations. Your knowledge about the PC's and the AT's limited buses are not directly transferable to Intel's hardware.

iAPX 286 Programmer's Reference Manual including the iAPX Numeric Supplement [80287], $14.95 paper, $19.95 cloth. Order Number: 210498-002. Available from Reston Publishing Co. If you are going to get only one volume in the 286 trilogy, this is the one to buy. The intricacies of the 286 and 287 are described from a programmer's viewpoint. Detailed information, with programming examples, is provided about topics such as memory management in terms of iRMX and Multibus. Known incompatibilities between the 8186/87 and 286/287 are listed. The full instruction set for both chips is provided, with information about their use in both the real address and protected modes.

iAPX 286 Operating System Writer's Guide, $15. Order Number: 121960-001. Again, detailed and invaluable information about multitasking, memory protection, virtual memory, real memory management, data sharing and message passing is provided. Programmers and systems analysts will find it invaluable as a source of information on issues such as running applications under a multiuser operating system. Sample source code is provided to illustrate programming tasks. This is a clear second choice to supplement the *iAPX 286 Programmer's Reference Manual* since it provides insights into the implementation of a multi-user operating system for programmers.

An Introduction to the Intel 286 Concepts and Ar-

chitecture, (tentative publication date, December 1984), $16.95 paper, $24.95 cloth. Available from Reston Publishing Co. Intel is producing the book and Reston is distributing it. To paraphrase from Reston's advance description of the book, this book is an explanation of the fundamental concepts governing the architecture of the 286. The architecture is then described in terms of its implementation in operating systems and applications programs. Multiple illustrations, examples, and an extensive glossary are used to provide an easy introduction to sophisticated concepts. If the description is accurate, users and programmers will have an accessible primer for complex topics.

iAPX 286 Architecture Extension Kernel (K286) User's Guide, $29. Order Number: 121961. I have not yet seen the book on the kernel for Intel's 286 operating system, but the kernel of a multiuser operating system, even Intel's, could offer invaluable insights for applications programmers. The kernel is always resident to perform essential operations and services.

"8207 Advanced Dynamic RAM Controller." Order Number: 210463-003.

"Interfacing the 8207 Advanced Dynamic RAM Controller to the iAPX 286." Order Number: 230862-001.

"8206-216 Bit Error Detection and Correction Unit." Order Number: 205220-004. Intel plans to use these two chips with the 286 for managing large memory arrays at speeds of up to 16MHz. But IBM and other OEMs are eclectic when it comes to building new machines. The 8207 works with 16, 64, and 256KB RAM chips.

OTHER INTEL MATTERS

Intel has, with DEC and Xerox, been one of the prime movers and developers of EtherNet. So, it is not surprising that Intel would develop the 82586 and 82501 chips set to lower the cost of implementing EtherNet. The first pamphlet has the hardware data sheets for the set, along with other information. The other two are reprints of technical articles on EtherNet's architecture. The 82285 is for use with the 82586 and the 82730 coprocessors (see below).

"The Complete VLSI LAN Solution." Order Number: 210783-001.

"Local Network Architecture Proposed For Work Sta-

tions." Order Number: 210262-001.

"System-Level Functions Enhance Controller IC." Order Number: 210788-001.

"82285 Clock Generator and Ready Interface For I/O Coprocessors." Order Number: 230813-001.

"82062 Winchester Disk Controller." Order Number: 210446-001. Winchester disks are to LANs what butter is to bread. This controller is compatible with the Seagate ST506 and Shugart SA 1000 interfaces. Intel's new text, graphics, and video controllers are compatible, of course, with the 186 and 286.

"82720 Graphics Display Controller." Order Number: 210655-002.

"82730 Text Coprocessor." Order Number: 210921-001.

"82731 Video Interface Controller." Order Number: 210925-001.

Finally, in the 1985 editions, Intel has broken the older two volume set of the "Peripherals Data Catalog" and the "Components Data Catalog" into multiple volumes. The 1984 editions are single topic handbooks. The following handbooks have all the germane application notes, article reprints, data sheets, and design information.

The Memory Components Handbook, $18. Order Number: 210830.

The Microsystem Components Handbook (2 volumes), $25. Order Number: 230843-001. This one has all the hardware information on the 8086/88, 186/88, and the 286/87, and many other chips as well. More than 2,200 pages long, you may prefer to spend $20 to get all the hardware data sheets, article reprints, and application notes in this bibliography, which has been bound for conveniency. Also, there are many items, such as article reprints about the text and graphics chips, that you could only find through extensive research in a good library. These two volumes provide encyclopedic reference work for more than 70 chips. There is a minimal overlap between this set and the 186 and 286 Reference Manuals.

The Telecommunications Handbook, $10. Order Number: 230730-001.

OTHER THAN INTEL

Osborne, Adam. *8089 I/O Processor Handbook*. Osborne Books. Programmers will find this book a useful supplement to the Intel manual listed above. The 8089 badly needs advocates. Any volunteers for missionary work?

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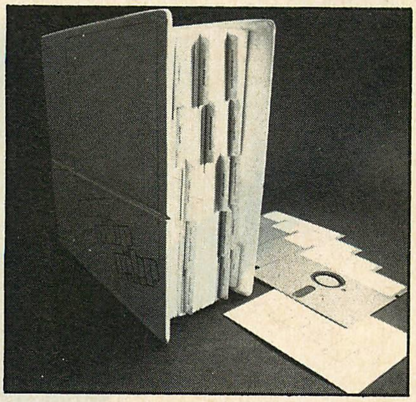

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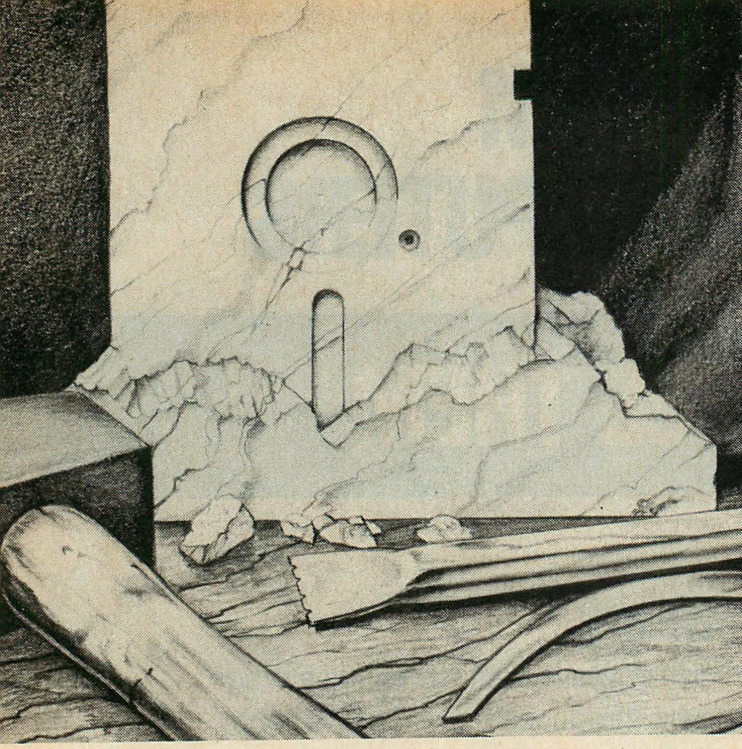

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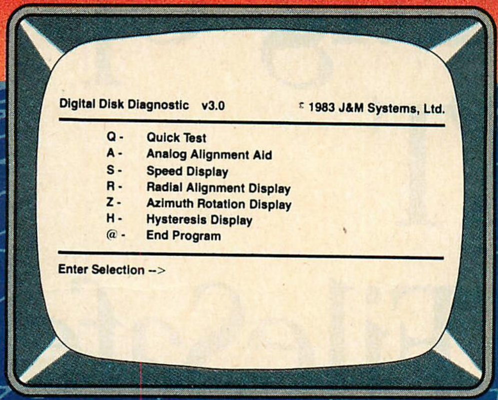

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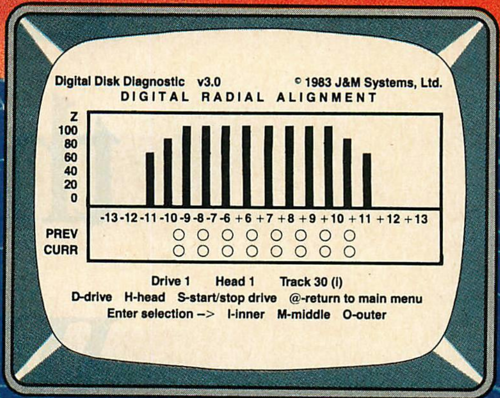

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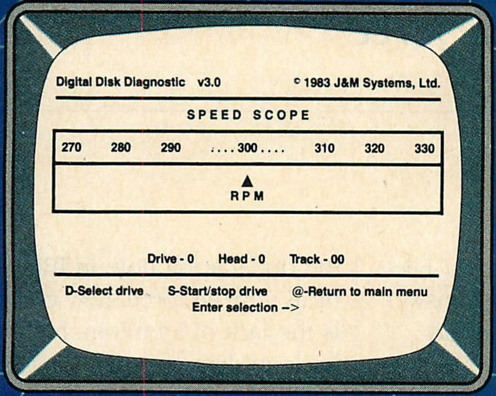

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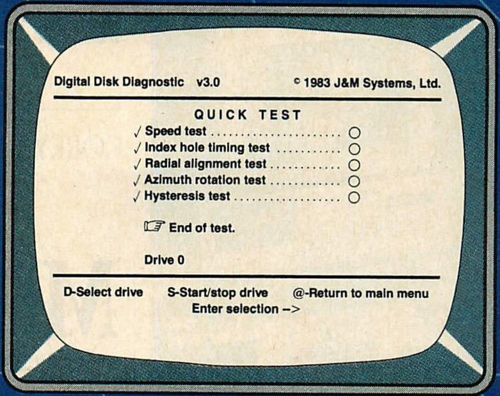

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Backing Up the AT with FileSafe

Mountain Computer's tape back-up fills the one glaring hole in IBM's new technical tour de force

C
COREY SANDLER

Mountain Computer's AT-FileSafe Tape is the first answer to IBM's good news/bad news PC/AT. The good news is that inside every Enhanced PC/AT, IBM has neatly packed 20MB of quick, ready-to-use, DOS-accessible permanent disk storage. That is 21,309,440 characters of information—roughly 4 million words, or 2 million names—or 20,000 1KB personnel files. What a solution to the problem of scattered floppy disks and the needs of a network file server!

Now, the bad news. Just imagine if one day your fixed disk simply would not compute. Nothing, not even IBM, is permanent, and the PC/AT has raised the stakes for computer users. Crashing a 20MB fixed disk could ruin your whole day—or your whole year.

And finally, some good news again. In the opinion of many users, the one glaring hole in IBM's technical tour de force, new computer is the lack of a built-in, high-speed back-up device to guard against mechanical failure. So, we were pleased to find that the first third-party peripheral device announced and delivered for the PC/AT was a streaming tape back-up system.

AT-FileSafe Tape (FileSafe for short) from Mountain Computer, seems to fit the bill quite nicely. It works simply, reliably, and quickly, according to the company; its recording and playback speed is about one-third faster than the data I/O speed of the fixed disk sold by IBM with its new computer. We hit the return key and watched as FileSafe dumped 20MB of data from a PC/AT in just over 6 minutes. The

Corey Sandler is an editor and writer of computer books who lives in New York.

unit can also make selective back-ups of work performed on a particular day, or of files modified since the last back-up. And, back-ups can be made from the AT's 1.2 MB, high-capacity floppy disks or from standard 360KB drives. (The unit is also claimed to be compatible with any standard PC-DOS-compatible network, although that feature was not tested for this review.)

I took the company at its word and copied a full PC/AT fixed disk onto a FileSafe data cartridge. I then took a deep breath and reformatted the fixed disk. I loaded the FileSafe cartridge back into its slot, booted the restoration program in the AT's floppy-disk drive, and typed R for restore. In just over 6 minutes, the fixed disk was once again packed with 20.3MB of data, including part of this article.

The FileSafe unit tested by *PC Tech Journal* mounts in one of the two half-height floppy-disk drive bays on the AT; the device, priced at $1,595, can hold as much as 27MB of back-up material. Another unit, priced at $1,695, can hold up to 60MB of data. External units, with their own power supplies and cases, sell for $2,195 and $2,395 respectively. These external units were the first such products offered by Mountain Computer, and were aimed at users of IBM's PC/XT.

HOW FILESAFE WORKS

A streaming tape back-up system is a high-tech version of the home audio cassette tape recorder. But while an audio cassette tape travels at a snaillike inch-and-seven-eighths per second, the computer equivalent zips along at 90 inches per second, transferring about 90KB of information per second along a single track of a ¼-inch magnetic tape (or more than 4MB per minute in actual back-up). At the end of the 600 feet on the standard cartridge, the tape reverses direction, the recording head shifts a notch, and the transfer of information continues. (The resulting back and forth continuous line of data is referred to as a "serpentine" track. The 27MB unit lays down four tracks; the 60MB unit uses nine passes.) The controller card includes error-correction logic with claimed reliability of less than one non-recoverable error in ten billion (10^{10}) bits.

Data are transferred from disk to streaming tape through the computer's RAM, using as much of the computer's free memory as is necessary, with the aid of one of the computer's DMA channels. The FileSafe controller circuit board can be strapped with a pair of jumpers and the software can be configured to use DMA channels 1, 2, or 3 (channel 0 is reserved for memory refresh). The user's only concern is to be certain that the controller does not attempt to use a DMA channel that the computer might seek to use at the same time for a second purpose. If there is a problem with shared use of a DMA channel, the program allows creation of RAM buffers, a procedure that could double the amount of time required for a back-up or restore operation. The card and tape unit supplied to us by Mountain Computer used DMA channel 1.

The streaming tape recorder seems well-protected against errors: the tapes will not lock into place if they have been installed incorrectly (that is, either upside down or reversed).

The tape cartridge for the FileSafe is 3M's 600A type (with 600 feet of quarter-inch tape). The cartridges sell for about $35 from commercial suppliers. The streaming tape recorder seems well-protected against errors: the tapes will not lock into place if they have been installed incorrectly (either upside down or reversed), and I tried to crash the system in several different ways, including opening the front latch and popping out the cartridge while it was in the midst of recording. No problems arose, other than an aborted operation here and there. And the cartridge itself includes a writeprotect slot that can be engaged or disengaged simply with a screwdriver or pen point.

The FileSafe's controller card that mounts inside the PC/AT is said to be 100-percent compatible with PC-DOS 3.0. The streaming tape device, though it can be mounted in a disk drive bay, is independent of the computer's disk drive controller, and cannot be accessed directly from DOS. Instead, Mountain Computer provides a simple-to-use, menu-driven program that directs the actions of the streamer in backing up and restoring files. Commands can also be given directly from the system prompt of DOS—this would allow creation of a batch file for automatic back-up at the end of a session with the computer.

Installation is very straightforward. The half-height unit slides easily into the second drive slot on the PC/AT, and connects via an internal ribbon cable to a full-length controller card. The first release of the controller card for the PC/AT would fit only in the second slot from the right because of its low "skirt" that would not clear double bus connectors on some slots of IBM's new machine. At the back of the controller card is a 25-pin, DB female connector for use with an external FileSafe unit. The streaming tape drive and controller card we examined were made for Mountain Computer by Archive, an established storage manufacturer, but a

spokesman for Mountain said other suppliers may be used as well.

FILESAFE CARE AND USE

The read/write head of the unit should be cleaned after each eight hours of use. If FileSafe is used once a day to back up a 20MB disk, the tape will actually be in use for about six minutes each day; this would make cleaning necessary only once every two months. The program supplied by Mountain also includes a subroutine which serves to "re-tension" a data cartridge. This procedure is recommended for any previously unused tape, tapes that have not been used for some time, and tapes that appear to be showing high error rates.

The FileSafe software is supplied on a floppy disk, although the program can be copied onto the fixed disk for storage and use. In an unusually-worded statement for a company whose product exists because of the possibility of failure of another device, Mountain suggests you keep a back-up copy of your FileSafe program diskette handy "in the unlikely event that you lose the entire contents of your fixed disk." In that case, you would need the FileSafe commands to access the data stored on the back-up tapes.

The FileSafe Command Menu has four main selections and provides entrance to special submenus. The standard options are:

B—Back-up DOS Partition to FileSafe Tape
R—Restore to DOS Partition from FileSafe Tape
F—Restore Individual Files to DOS Partition from FileSafe Tape
D—Directory of FileSafe Tape Files

To gain access to submenus, the user is asked to enter one of the four letters followed by a "+".

Entering commands directly from DOS follows a similar logical organization. And other parameters can be added, including the drive letter for the file to be backed up, the use of DOS subdirectories, addition of a label to the partition to be backed up, and others.

TESTING THE UNIT

In order to test the unit, I filled a PC/AT fixed disk with a mix of files. Five subdirectories held approximately 245 short files of varying lengths, including all of DOS 3.0. I then created a sixth subdirectory and filled it with about 70 copies of a 225KB database file.

I loaded a FileSafe cartridge into the streaming tape drive, loaded the back-up program into the PC/AT's high-capacity diskette drive, and gave the command for backing up the entire fixed disk. From the moment I booted-up FileSafe's command menu until the

moment the streaming tape drive finished its work, elapsed time was 6 minutes 11 seconds. (The actual time for the work of the drive itself was just over 5 minutes.)

After completion, the program displayed a status report:

DOS Partition back-up successfully completed.
Performance statistics:
Total Data Backed-up >>> 21309440 bytes
Elapsed Time >>> 307 seconds
Average Data Rate >>> 4164660 bytes/minutes
Streaming Efficiency >>> 75 percent

The "efficiency" score is a representation of the rate at which the data was transferred in comparison to the optimal rate of the streaming tape drive. In this instance, the streaming tape drive was running about one-third faster than the fixed disk's output, and was forced to pause every once in a while to allow the PC/AT to catch up. When I later restored the contents of the tape cartridge, the data efficiency and speed were nearly identical.

How does this compare with the fixed-disk-to-floppy-disk back-up procedure offered by IBM in PC-DOS 2.0 and 3.0? I took the same 20.3MB of information and used the PC-DOS 3.0 "BACK-UP c: a: /s" command to dump the contents to a series of floppy disks. What I discovered is that the speed of transfer is greatly affected by the length of the files being copied. For example, the computer started out by copying the series of small files at the beginning of the fixed disk. The first transfer, of 91 files, took 4 minutes 18 seconds to fill a single 1.2MB high-capacity floppy disk. Later, when the computer entered my subdirectory of 225KB database files, transfer speeded up considerably to about 1 minute 18 seconds for each disk filled.

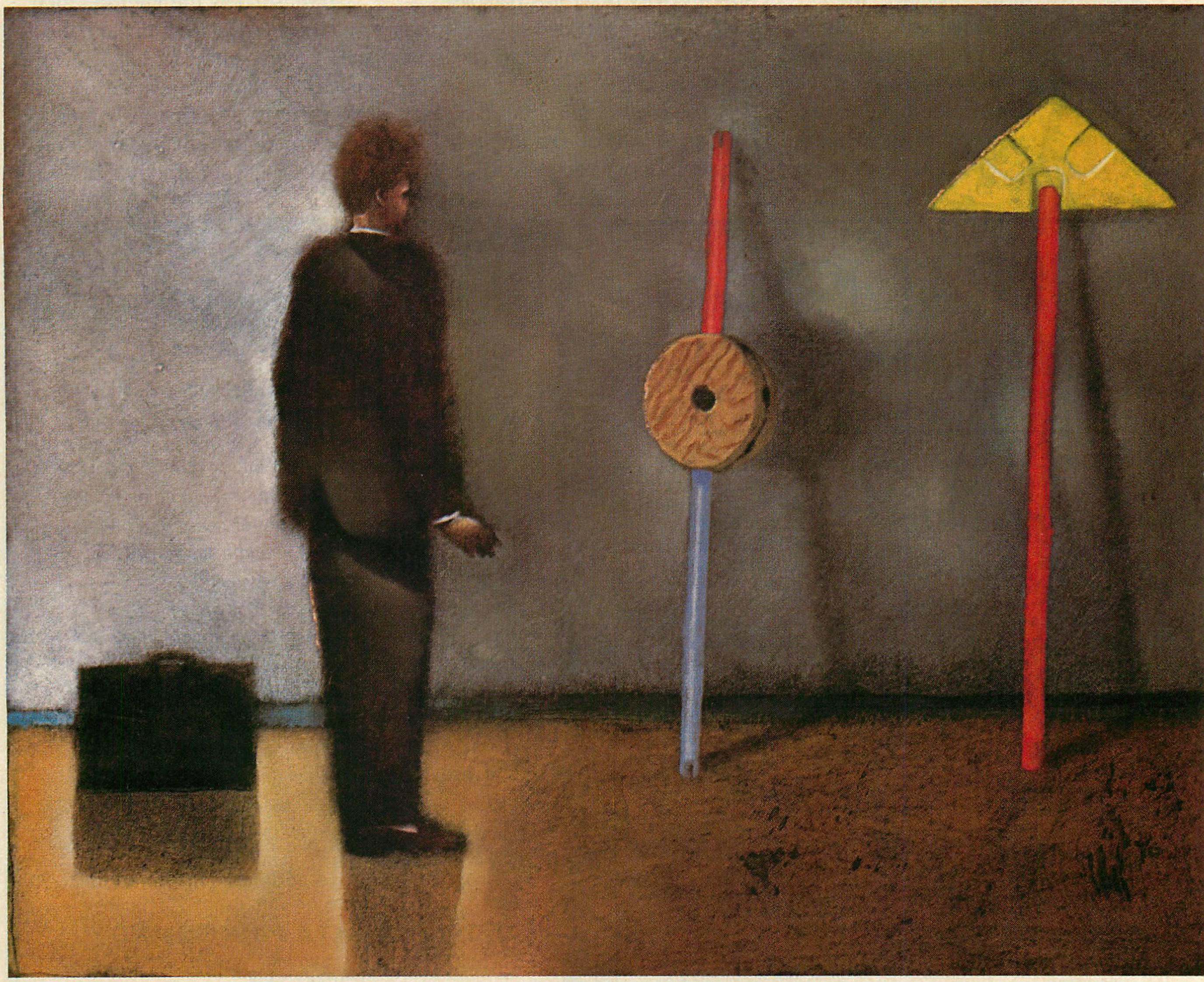
The total time required to back-up the 20.3MB of data on 18 high-density floppy disks was about 31 minutes. If the disk had been filled with more of the smaller files, the transfer time would have been considerably longer. And, I have not included in the timing the 1 minute 19 seconds DOS 3.0 required to format each disk before use.

It should be pointed out that very few users create or change megabytes worth of information in any individual computing session, and that IBM's BACKUP and RESTORE commands can be made more specific so that the computer is instructed to make archive copies of only those files that have been changed or created since the last time a back-up was performed.

The decision to purchase and install a specialized back-up drive system, such as the FileSafe, then, would seem to be a matter of cost and convenience. AT-FileSafe Tape is clearly the more expensive option, but is also obviously more convenient than manual back-ups with PC-DOS and floppy disks.

Modular Implementations

Three compilers fare well, but compare very differently in their implementations of high-level Modula-2.



TOM WOTEKI,
ALAN FREIDEN,
DOV LEVY,
THOR BESTUL,
and
ROBERT STINE

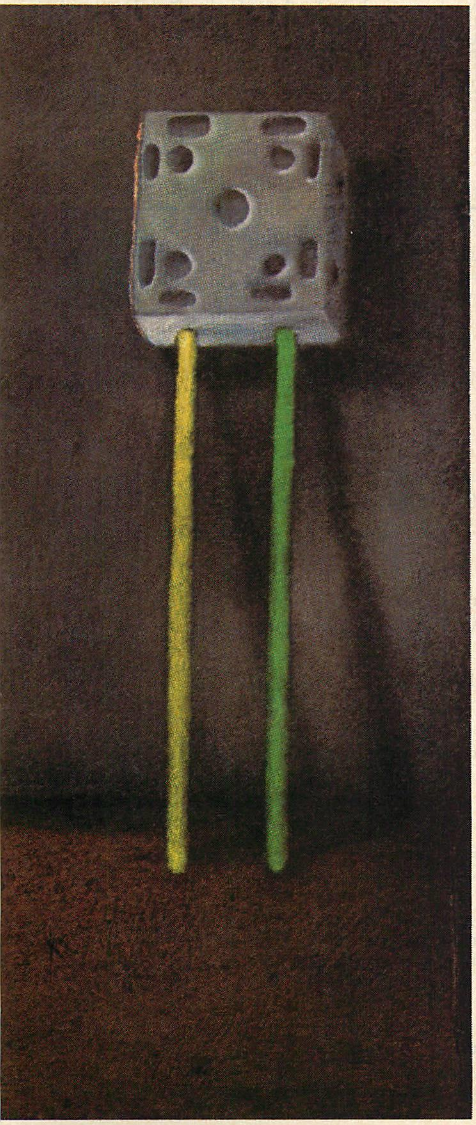


ILLUSTRATION • MARK PENBERTHY

Among our considerations as we explored the capabilities of the high-level programming language Modula-2 (*PC Tech Journal*, November 1984, page 72) was that its advantages are best realized only through a good implementation. We suggested that a good implementation of Modula-2 would include five characteristics: a full implementation of all high-level features, a good implementation of the low-level facilities, native-code compilation capabilities, a good relationship between the implementation and the *de facto* standard operating system on the computer, and implementations of the language's standard library modules.

With these in mind, we will now take a look at three Modula-2 compilers: one from Logitech, Inc., one from Volition Systems, and one from the Modula Research Institute. There are significant differences among the three, offering a wide range of choices to users.

Tom Woteki and Alan Freiden are principals of Information Systems Inc. Dov Levy and Thor Bestul are staff programmers for the same firm. Robert Stine teaches at the University of Pennsylvania. This is the second of two articles by the authors on Modula-2. The first, which appeared in the November 1984 issue ("Modular Constructions," page 72), examined Modula-2's specific features and compared it to other programming languages.

THE LOGITECH COMPILER

The compiler from Logitech, Inc. that we reveiewed is the Modula-2/86 release 1.0. This is a four-pass compiler modeled after the compiler for the Lilith computer. It runs under PC-DOS/MS-DOS 2.0 and 2.1 and generates relocatable native code. Included are a linker, for link-editing separately compiled modules; a program loader, M2; an easy-to-use postmortem symbolic debugger; and a large number of utility and standard library modules.

To run a program using the system, first create the text for the program using your favorite editor. Then, run the text through, use the linker with the compiler output to link in the code for any modules imported by the program, and run the program M2.EXE, passing it the name of the linked code file. M2.EXE, written in Intel assembly language, establishes a run-time environment, then loads and passes control to the desired program.

With Logitech's compiler, compilation of a library module involves separate compilation for its definition and implementation parts, but linking is unnecessary. In-

stead, the compiled definition module is an input to the compilation of any module that imports it, and the implementation part is used as input when linking a main program.

We gave this implementation the highest marks on four out of five of our criteria (see table 1). It scored especially well when judged on its low-level facilities (imported from the module SYSTEM), which are the best among the three compilers reviewed. In addition to the expected types ADDRESS and WORD and the procedure ADR, the facilities include the following:

- concurrent device programming via IOTRANSFER
- a procedure to generate in-line code for the 8086/88 by passing the hexadecimal code for the instruction
- a procedure to generate software interrupts by passing the interrupt type
- procedures to set and get the CPU's registers by passing the name of the register
- a procedure, DOSCALL, for making calls to MS-DOS functions by passing a function number and list of parameters.

Although the compiler seems to generate reasonably good code for a first release (see table 2), its overall operation is noticeably slow. Moreover, it is somewhat awkward to use on a dual-floppy computer due to the large number of temporary and intermediate files produced by the compiler and linker. A fixed disk, while not required to get started, will be very desirable if the system is used regularly for software development. We used the system on a fixed disk to organize the various files produced by the compiler and linker into subdirectories. We then used the DOS command SET to create an environment for the compiler and tell it which subdirectories we were using. This worked very well and improved significantly the performances of the compiler and linker. The use of the

TABLE 1: *Summary Comparison of Compilers*

CRITERIA	COMPILERS: LOGITECH	VOLITION	MRI
High-level features	A	A	A
Low-level facilities	A+	B	C
Native code	Yes	No	No
Relationship to MS-DOS	B+	C	B−
Library modules	A+	A+	B

TABLE 2: *Benchmark Comparisons*

	NATIVE CODE COMPILERS: MICROSOFT PASCAL SECONDS	MICROSOFT PASCAL RATIO	MS-C	LOGITECH MODULA ✓ OFF	TURBO PASCAL	LOGITECH MODULA ✓ ON	PSEUDOCODE COMPILERS: SOFTECH UCSD PASCAL	VOLITION MODULA	MRI MODULA
LOOPS									
Repeat	36	1.00	1.00	1.36	1.47	1.64	11.39	15.98	21.36
While	38	1.00	1.18	1.34	1.47	1.61	14.03	19.42	22.05
For	34	1.00	1.29	1.21	1.18	1.21	16.59	12.68	7.59
CARDINAL ARITHMETIC	137	1.00	1.12	1.09	1.12	1.25	4.41	6.08	7.69
ARRAY INDEXING									
1 Dimension	96	1.00	1.03	1.74	1.86	2.91	31.25	33.15	30.35
2 Dimensions	110	1.00	***	1.28	1.18	1.74	12.65	11.73	12.22
PROCEDURE CALLS									
0 Parameters	95	1.00	0.37	1.06	2.29	1.18	12.44	12.78	14.23
4 Parameters	151	1.00	0.90	1.20	1.89	1.27	10.11	11.04	14.42
BLOCK MOVE	214	1.00	***	1.01	1.38	1.01	1.20	1.20	4.77
POINTER CHAIN	128	1.00	1.00	4.95	3.19	4.95	8.70	10.81	14.17
ERATOSTHENES SIEVE	12	1.00	***	1.25	***	1.58	19.50	19.17	17.00

A pair of benchmark programs was executed using each compiler. The Modula-2 versions are listings 1 and 2. An execution time for a compiler is expressed as the ratio of its time to that of Microsoft Pascal measured in seconds. Each timing was performed using a hand-held stop watch. Measurements are believed to be accurate to within one second.

✓ off = run-time checking off   ✓ on = run-time checking on (index, range, stack)
Unless otherwise noted, range checking is assumed to be on.

Microsoft Pascal was tested with run-time checking on and off. No measurable differences were observed.

SET command is described in the Logitech documentation.

The compiler generates code to address the full megabyte of 8086 memory, which can be arbitrarily allocated between code and data. Furthermore, the system supports program overlays, or subprograms. These are merely programs that are written and compiled the way any other program is, but are called from another program. Programs and subprograms can share data and code provided they are linked appropriately. Subprograms are loaded via a call to a procedure in a supplied library module. The loading procedure allocates memory to subprograms using a stack-based architecture; in effect, the called program becomes a procedure to the caller. Subprogram calls may be nested. Further details on this process are as follows:

A *main* program may occupy as much code as necessary up to the limits of memory. Any remaining memory (exclusive of the operating system) is divided among a global data segment, a program stack, and a user heap. The global data segment is used to store the global, static variables used by the program and may be up to 64KB in size. The stack is used to store procedure parameters and local variables and temporary values during expression evaluation; it varies in size during execution, up to a maximum of 64KB. The heap is where the user and the system allocate dynamic data, which may occupy as much memory as is available. Therefore, a program may allocate an arbitrary amount of dynamic data, up to the limits of memory. The four segments—code, data, stack, and heap—comprise the entire program's workspace. When a program is loaded, M2.EXE allocates all of the available memory to the program workspace.

A subprogram is loaded by invoking the procedure Call in the library module Program and passing it the name of the subprogram. Call loads the subprogram at the top of the calling program's stack and allocates to it as large a workspace as possible. The limits on a subprogram's workspace segments are the same as those for a main program, so an overlay may have its own 64KB global data segment, and its total workspace is limited only by the available physical memory.

We gave the Logitech implementation the highest marks on four out of five of our criteria. It scored especially well when judged on its low-level facilities.

The compiler produces code for the 8087, but there is no software emulation. One must have an 8087 to execute programs employing floating-point operations, although the compiler will compile programs that use floating point even without an 8087.

LOGITECH BUGS

This compiler has some bugs; we crashed it using some of its low-level facilities. Overall, these were not serious problems, because they had simple workarounds. The compiler also had some problems coping with complicated expressions, although it was able to recover gracefully: it issued a syntax error flagging the expression it didn't like. The second problem is arguably not a bug since the compiler did not crash; but whatever they are called, these problems should be eliminated.

To illustrate the first problem, consider the following fragment where ADR returns the address of any variable passed to it:

```
FROM SYSTEM IMPORT ADR;
TYPE
  Address86 = RECORD
                offset  : CARDINAL;
                segment: CARDINAL;
              END;
VAR
arg  : INTEGER;
  pArg: Address86;
BEGIN
  pArg:= Address86(ADR(arg));
END;
```

This fragment is intended to extract the address of the variable arg and convert it to a record of the type Address86 so that the individual components of the address may be accessed. Applying the type identifier to the result of ADR should do this. Instead, the compilation is aborted: the compiler chokes and invokes a very low-level error handler that produces some reference numbers and requests the user to contact Logitech. It's a good news/bad news situation: the bad news is that the compiler is broken; the good news is that you can tell Logitech exactly what happened!

OTHER CONSIDERATIONS

Although we considered it to be the best of the three compilers we reviewed, the Logitech compiler earned only a so-so grade on its relationship to MS-DOS/PC-DOS, the excellence of its low-level facilities notwithstanding. Logitech's system does reside wholly within the DOS environment, supports command line arguments (both in the compiler and in user programs), and input/output redirection, and it uses the MS-DOS file system. But the compiler does not produce Intel format object files. Instead, the user executes M2.EXE in order to execute applications programs. We see no reason why the linker could not bind M2.EXE into a compiled program, although this would increase the size of the final code file.

One unfortunate aspect of this incompatibility is that 8086 assem-

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bly language cannot be directly linked to a Logitech Modula-2 program. Granted, Modula-2 is a powerful systems programming language, and its implementation has excellent low-level facilities, including in-line 8086 code generation. Nevertheless, we would still like to have the capability to link to assembly language (especially for graphics). The possibility exists to link assembly language routines to the run-time loader, M2.EXE, and calling them via a software interrupt, but no documentation is provided.

We gave this implementation highest marks for its library modules; more than two dozen utility and standard library modules are supplied, several of them in source form. Included are a standard dynamic memory management module; a standard module to load program overlays; one to schedule quasi-concurrent processes; a group of modules for keyboard and console I/O; a group for creating, opening, and closing files and performing sequentially formatted I/O; a simple floating-point math library for transcendental functions; and modules for converting integers and cardinals to hexadecimal, decimal, and octal strings and vice versa.

String constants are defined in Modula-2, but the type *strings* is not a predeclared data type. String variables may easily be implemented as arrays of characters, but support for string operations must be supplied by the vendor or the programmer. Logitech supplies a module for manipulating strings and the I/O modules support string use.

Logitech supplies three library modules for performing serial I/O that could form the foundation for a telecommunications program. All three are provided in source form, but they differ in their implementations. One uses polling, one implements interrupt-driven I/O using IOTRANSFER, and the third replaces the ROM RS-232 interrupt handler with a procedure written in Modula-2 and in-line code and avoids even the overhead of IOTRANSFER (but is not portable to other Modula-2 implementations). The latter two are interesting examples of the power of Modula-2 for programming at a low level.

Logitech supplies a postmortem symbolic debugger with the system. Whenever a program aborts, or the

If the availability of a sound, elegant, and uniform implementation of Modula-2 on a variety of computers is important to you, then the Volition Systems compiler is an excellent choice.

intrinsic procedure HALT is called, or Ctrl-C (BREAK) is typed, the run-time system dumps the memory to a disk file. The dump, together with files produced by the compiler, becomes input to the debugger, which can then examine the contents of variables, find the line of source code at which the abort occurred, examine source and object code in the area of the offending line, and traverse the chain of procedure calls to that line.

The Logitech documentation is minimally adequate and could stand to be expanded and edited. It is particularly weak in describing both the use of the linker with program overlays and the run-time environment. Complete source code for the program M2.EXE is provided, but there is no documentation (other than the comments in the listing). M2.EXE could be modified to suit special requirements, but this would require a better explanation of how it works.

We called Logitech for help with our problems. The technical support was excellent and was offered in a congenial manner. (The company was not aware that we were in the process of reviewing its Modula-2 compiler.)

Generally, we were favorably impressed with this implementation, although, as described above, several improvements are needed.

VOLITION SYSTEMS

This is much more than just a compiler. It is a complete operating system comprising a Modula-2 compiler (release 0.3p for the IBM PC), a UCSD Pascal compiler, an excellent program editor (Volition's Advanced System Editor), a file-handling utility, and other utilities, including librarians for managing the object files produced by the compilers. The system is based on the UCSD p-System, version II.1. It may be used in two modes: as a stand-alone system, or as a subsystem running under DOS 2.0 or 2.1.

As far as we know, the Modula-2 compiler is Volition's own design and was originally written in UCSD Pascal. Volition has considerable experience in this area, and we consider the compiler to be highly reliable. Unfortunately, it produces only pseudocode—machine code for a virtual p-machine, emulated by an interpreter written in the assembly language of the host machine and supported by an extensive run-time system. The run-time system calls the 8087 for floating-point support (an 8087 is necessary to execute programs employing floating point operations). The run-time support software is, of course, part of the Volition package.

There is an advantage to this approach: p-code interpreters are relatively easy to write. Therefore, it is fairly easy to port the Volition Systems compiler in its entirety from one computer to the next. For example, the Volition system is also available on the Apple II and III

computers and the MC-68000-based family of Sage computers.

NO CONNECTION TO DOS

If the availability of a sound, elegant, and uniform implementation of Modula-2 on a variety of computers is important, then the Volition system is an excellent choice. Unfortunately, its implementation on any given host computer is apt to suffer in comparison with other Modula-2 systems that are more closely host-related. Three areas in which this is obvious are: program execution times, connection to the *de facto* standard operating system, and low-level facilities. Execution times will be discussed in the next section; for now we will look at the other two points.

When used as a stand-alone system, the Volition compiler has no connection to PC-DOS. In this case, the system is booted from a non-DOS disk, and it reads and writes on floppies using a different directory layout and file allocation plan than DOS, so its disks are foreign to DOS. The stand-alone mode has no fixed-disk support, but it does have RAM-disk support.

Using the system as a subsystem to DOS means that it is booted to from DOS, that fixed-disk support is available, and that user programs may read from and write to DOS files, although key system support programs, such as the program editor, cannot.

The Volition system is invoked from DOS by executing a supplied utility program. Thereafter, DOS completely disappears and is replaced by the Volition environment. All program development takes place in this environment. DOS utilities are not only unusable, they are irrelevant. Program execution is under control of the interpreter-based subsystem; the user cannot transfer a code file to DOS and execute it from there.

In subsystem mode, fixed-disk support is available using *virtual*

volumes. A virtual volume is a preallocated DOS file of fixed size stored on a DOS partition of the fixed disk or on a floppy. It appears as a file to DOS, but appears as a disk volume to Volition; the internal structure of the file matches that of a Volition floppy and includes the directory needed to organize the volume. The program and data files stored in the virtual volume are accessible to the Volition system, but not to DOS. Further, not all virtual volumes a programmer may have created are accessible at all times. The names of specific volumes to be accessed must be supplied to a configuration utility program.

The stand-alone version of the Volition system works very well on a dual-floppy PC, especially when memory is available to implement a RAM disk. The DOS subsystem mode seems better suited for use on a PC equipped with a fixed disk, although we were able to run it on just a dual-floppy system. We should note, however, that we did have some problems starting up our floppy-based subsystem. The documentation explaining the configuration and start-up of the system is confusing, and we endured a few false starts. This is a weak spot in otherwise excellent documentation. (Note also that we are experienced p-System programmers who have worked with earlier versions of the Volition system.) It is possible to configure the subsystem to be a turnkey system, so that what appears to a user to be a DOS application actually involves transparently booting the subsystem, then executing the application under it.

All in all, we gave the Volition system average marks on its relationship to PC-DOS. We stress, however, that it is possible to have applications programs read and write MS-DOS ASCII and other data files.

A DIFFERENT ORIENTATION

We gave the Volition system a so-so grade on the relationship of its low-

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level facilities to the host computer. The reason is that key system facilities, imported from the module SYSTEM, are oriented toward the virtual p-machine, not the IBM PC. Although Volition does provide a number of library modules to access the PC's resources, the orientation of the system is toward the p-machine and not the PC.

For instance, the type ADDRESS and the function ADR refer to 16-bit addresses within the data space of the p-machine, not directly to locations within the PC's memory. And, although there is support for device interrupt handling via IOTRANSFER, the interrupt system is, presumably, that of the p-machine, not the PC. To wit: there are eight prioritized interrupts, and their numbers do not correspond to interrupts used for similar services under DOS. This is true whether or not the system is used as a subsystem to DOS. Furthermore, there appear to be no facilities for calling DOS, even when in subsystem mode.

Counterbalancing this is the ability to generate in-line 8086 machine code (no assembler is included, and linking assembly language routines to Modula-2 code is not possible) and the availability of two library modules to access the PC's resources. One module provides procedures to peek and poke physical memory locations and to read and write I/O ports. The other provides routines to control attributes of the video display.

The memory model for this system is also oriented toward the p-machine: a computer with a 64KB data space and unlimited memory for code. Therefore, the only limit on the size of a program's code is the physical limit imposed by the host computer. As for data, a program's data space comprises a global, static data segment, a stack, and a heap. The three segments play roles simlar to those played in the Logitech implementation except that all three segments reside in a

single, logical 64KB area. Therefore, the total space for data is limited to 64KB whether the data are static or dynamic. Program overlays are permitted and are handled as they are for Logitech, but unlike the Logitech scheme, a subprogram in this system does not have a separate data space. Overlays may share data and code with their callers.

The library modules supplied by Volition are similar in variety and function to those supplied by Logitech. They include libraries that provide I/O services and string handling. Volition does not supply an RS-232 serial communications module; instead, it supplies the source code for a simple terminal program that will at least get the user on the air. In addition, more than two dozen simple, sample programs, are supplied, all in source form, along with a number of utility programs. The sample programs, which are referenced in the documentation, illustrate various Modula-2 programming techniques. The utility programs include such useful items as a byte-level file editor, a shell program that supports a UNIX-like command shell, and a batch command interpreter. We gave high marks to Volition for the library modules and utilities.

Aside from the problem mentioned above, we found Volition's documentation to be excellent. It contains a brief tutorial on Modula-2 (the only one of the three to do so), and an excellent description of how to use its system. The tutorial is coordinated with the sample programs. Our calls to Volition Systems for technical support were handled by knowledgeable, pleasant people.

The p-System operating system is a convenient, elegant, and well-integrated program development system, and Volition's implementation is no exception. If it were not for what we consider to be major shortcomings cited above, this system unequivocally would be our first and only choice among the

three Modula-2 implementations. (Note that some of the low marks Volition received are due to our evaluation criteria. If we had placed system and software portability and ease-of-use above other criteria, Volition could easily have come out with higher marks.)

THE MRI COMPILER

The compiler from the Modula Research Insitute (MRI) is the M2M-PC version 1.34. It is a four-pass compiler modeled on the Lilith compiler. Indeed, it generates m-codes—the actual machine instructions for the Lilith—that are interpreted at execution time. We gave this system high marks for language implementation; but, it has some other major shortcomings.

The MRI environment comprises a combination command and m-code interpreter that runs on top of MS-DOS. The command interpreter emulates Medos, the DOS on the Lilith; the m-code interpreter emulates the Lilith's CPU. To compile and execute a program, first boot MS-DOS and invoke the interpreter INTERP.COM. This establishes the run-time environment, which allows the user to execute the compiler or other Modula-2 programs. To edit a program (or invoke any PC-DOS command), type ! in response to the Medos prompt. This invokes a secondary copy of COMMAND.COM and PC-DOS becomes available. Use your favorite editor to create the text of a program; when done, type exit in response to the PC-DOS prompt to return to the Medos interpreter. Now invoke the compiler by typing modula. Upon successful compilation, type the name of the program. The Medos program loader loads the program and execution begins. All programs are executed by typing the name of the program in response to the Medos prompt.

The compiler produces m-codes for the Lilith computer, or m-machine, not code for the 8086/88. The low-level relationships between the compiler, the m-machine, and the PC are even more oriented toward emulation than in the Volition system: addresses refer to locations in the 64KB address space of the m-machine. There is no support for concurrent device programming (no m-machine interrupts are supported), but coroutines are supported via the type PROCESS and the procedures NEWPROCESS and TRANSFER. There is no facility for generating in-line 8086 code or software interrupts (although it is possible to link assembly language routines); instead, in-line m-code can be generated. And, unlike the Volition Systems product, the MRI compiler has no library modules that provide access to the PC hardware. The compiler does not support the 8087; all floating-point operations are emulated by software.

Assembly language routines can be called from Modula-2 by first

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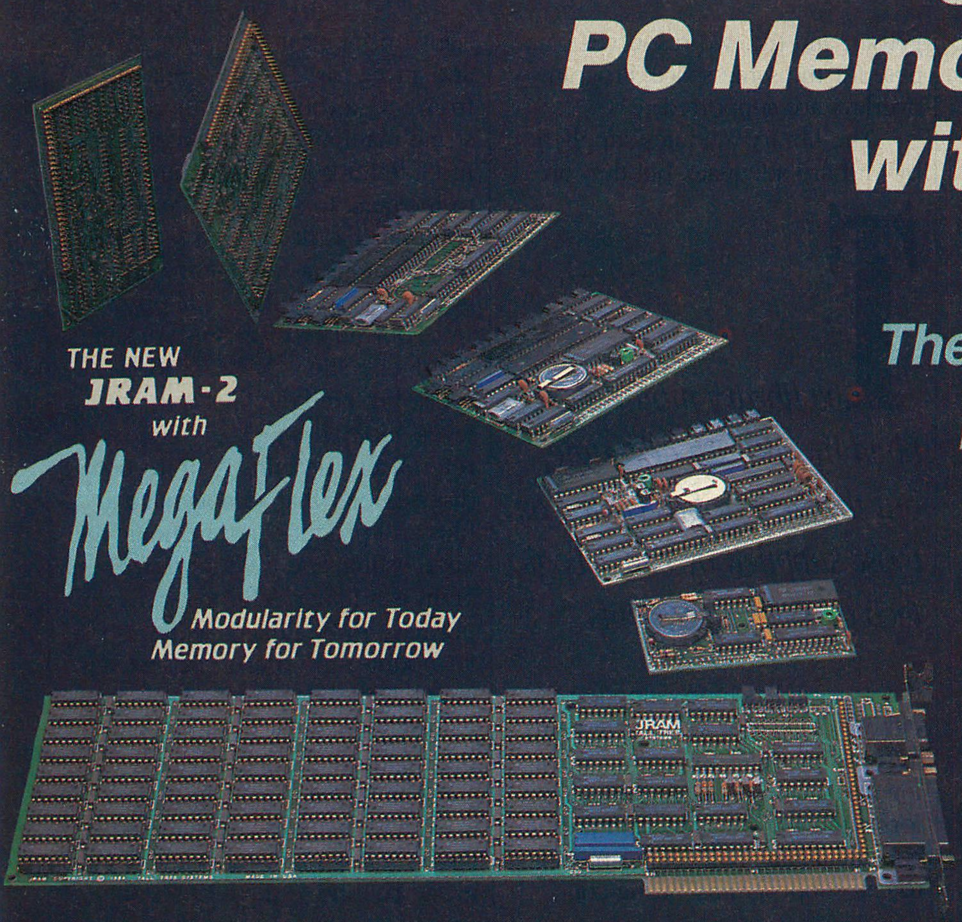

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linking them into the m-code interpreter. The interpreter is supplied in both linked and unlinked form; 256 routines can be linked to it. An assembly language routine is called by generating a special in-line m-code escape sequence.

The emulation of the Medos system is such that all files produced by the system are accessible under MS-DOS, so any of MS-DOS's file handling utilities can be used, and all of its file naming conventions are supported. Beyond this, however, there is no special relationship between the Medos environment and MS-DOS.

The memory model for this system is a computer with 64K words of memory. Within this space reside the stack and the heap. The heap plays the same role it does in the other implementations. The stack holds all static data, local variables, and expression evaluations; it also holds all code. Therefore, data and code are limited to 64K words altogether, and the two resources compete for the same space. Program overlays are supported.

The library modules supplied by MRI are adequate, but they are

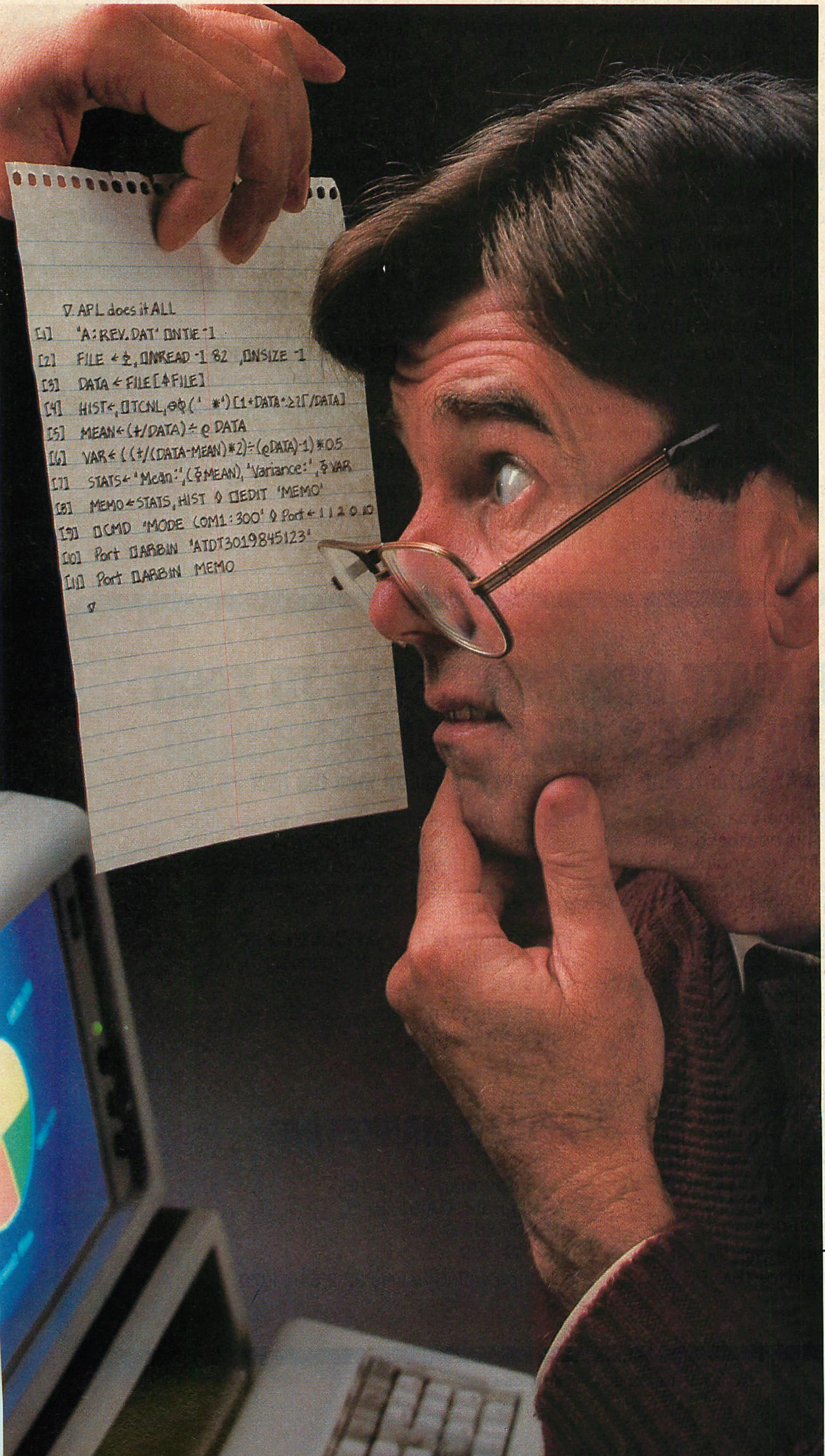
> *The library modules supplied by MRI are adequate, but they are not as varied as those supplied by either Logitech or Volition Systems.*

not as varied as those supplied by either Logitech or Volition Systems. MRI has modules to support opening and closing files, to perform formatted I/O with files and the console, to manage the heap, and to call subprograms. String constants may be output to the screen, and string variables may be read from the keyboard, but there is no string manipulation module and no module for converting from strings to integers. In addition, the MRI compiler has no process scheduling module, and no module or program to support the serial port.

Four utility programs are supplied: one allows the user to inspect, but not edit, files at the byte level; another is a program cross-referencer; the third is an m-code disassembler that accepts m-code files and produces a mnemonic m-code listing; and the fourth program is a linker. MRI programs do not have to be linked to their library modules in order to be executed. Unlinked programs are automatically linked at run time, but prelinking reduces load time.

The MRI documentation is good and includes an example that shows how to link an assembly language routine to the MRI system.

Tell this to your PC and see what happens.



No, it won't roll over and play dead. While the funny-looking symbols might not make immediate sense to you, to a PC equipped with STSC's APL★PLUS®/PC System they tell an amazing story. In just 11 lines this program describes a sequence of events that can't be accomplished by any other single software package.

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BENCHMARKS

We compared the three compilers among themselves and against several other popular compilers using some simple benchmarks. Microsoft Pascal release 3.13 was used as a standard compiler; it usually generated the fastest code; all other timings were relative to MS-Pascal. The results are summarized in table 2. Source code for the benchmarks is provided in separate listings.

The first 10 benchmarks (listing 1) test the compilers' codes for the most fundamental operations. Since all programs are built from thousands of these operations, these benchmarks give a reasonable first order estimate of the relative performance of the compilers. The last test, Eratosthenes Sieve (listing 2), is an algorithm for finding prime numbers, and is often used as a standard benchmark.

The results clearly separate the native code compilers (8086 machine code) from the pseudocode (p-code, m-code) compilers and illustrate the penalty paid for emulation. The pseudocode compilers are slower by at least a factor of 10 on most of the tests. An outstanding exception, however, is the block move. This operation, which involves the assignment of an entire array to another array variable, probably generates one pseudocode instruction that is neatly emulated by the 8086 string move instruction; it is not surprising that the execution time approaches that of the native code compilers.

Within the native code group, the results for the Logitech compiler were somewhat disappointing compared to MS-Pascal, although they did compare favorably to those for Turbo Pascal. We can only speculate as to the reasons: MS-Pascal is in its third major release. During this time the code-generation phase of the compiler has probably been improved. On the other hand, the Logitech compiler is only in its first major release. Perhaps it will also improve with age.

Curiously, we observed no difference in MS-Pascal, whether its error checking was turned on or off. However, the Logitech compiler benefited greatly on a percentage basis when its error checking was off. We did not test the other compilers with error checking off.

The following compilers were benchmarked in addition to the Modula-2 compilers: Microsoft Pascal, release 3.13; Microsoft C, release 1.04; Turbo Pascal, Borland International, release 1.0; and UCSD Pascal, Softech Microsystems, Inc., release IV.12.

IT'S YOUR CHOICE

We began this evaluation with specific criteria for judging the systems. None of the systems fully satisfied all of our demands, but Logitech came the closest. The Logitech system would completely satisfy us if it produced Intel format object code

and if it were a little faster. Certainly its low-level facilities are the best. Volition's system would be our first choice if the excellent tools it offers were better integrated with MS-DOS and if the compiler were able to generate native code. We offer these recommendations:

- If MS-DOS compatibility and native code generation are most important to the user, then Logitech is the only choice and, all things considered, a good one.
- If portability to other computers, ease of use, and convenience of the overall development environment are important, and the user can forego MS-DOS and native code, then Volition Systems' implementation is an outstanding choice.
- The user who is developing software for the PC on the PC may want to consider both the Logitech and the Volition compilers. (We use the Volition system to prepare source files and debug syntax errors, then transfer the sources to MS-DOS where we fine-tune the implementation using the Logitech compiler.)
- If the user just wants to see what Modula-2 is all about, then the MRI system might be the right choice, despite its shortcomings. For $40, it's a good introduction to the language. Moreover, for an additional $160, the source code for the compiler can be purchased. Then the user can really become a Modula-2 hack . . . that is, sculptor!

Modula-2/86, Release 1.0
Logitech, Inc.
805 Veterans Blvd.
Redwood City, CA 94063
415/365-9852
$495
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Modula-2 Compiler, release 0.3p for IBM PC
UCSD p-System, Version II.1
Volition Systems
P.O. Box 1236
Del Mar, CA 92014
619/270-6800
$395
CIRCLE 493 ON READER SERVICE CARD

M2M-PC Compiler, Release 1.34
Modula Research Institute
1673 West 820 North
Provo, UT 84601
801/375-7402
$40
CIRCLE 494 ON READER SERVICE CARD

REFERENCES

Weiner, R. and Sincovec, R. *Software Engineering with Modula-2 and Ada.* New York: John Wiley & Sons Ltd., 1984.

Wirth, N. *Programming in Modula-2.* New York: Springer-Verlag, 1982.

Wirth, N. "The Personal Computer Lilith." Reprinted by the Modula Research Institute, April 1981.

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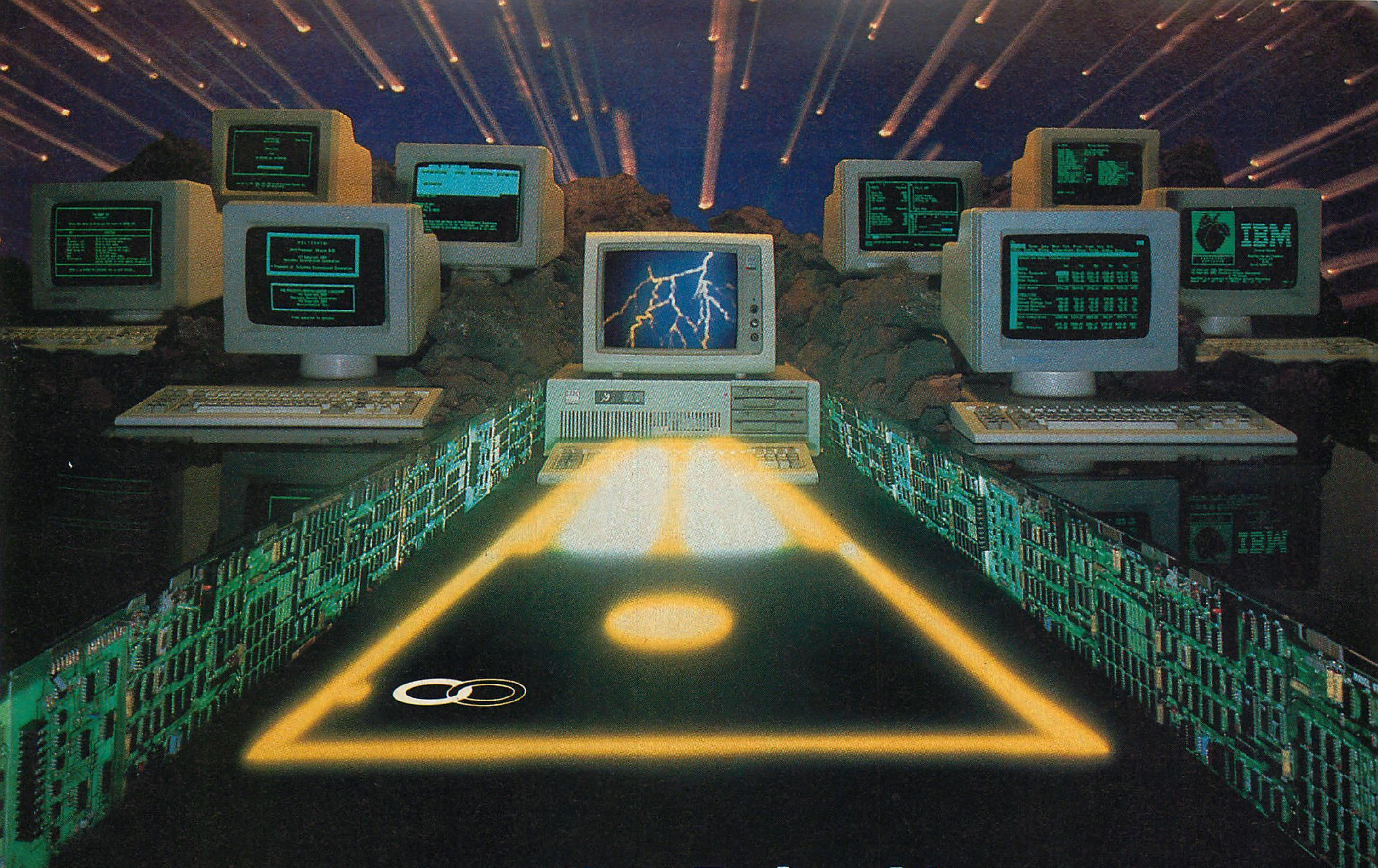
Pacific Datanet

LISTING 1: MODULE Benchmark

```
MODULE Benchmark;

(* This benchmark program (with minor changes)
   is from "The Personal Computer Lilith," by N. Wirth,
   Institute fur Informatik, ETH Zurich, 1981.          *)

FROM Storage IMPORT ALLOCATE;
FROM Terminal IMPORT Read, Write, WriteLn;

TYPE
  NodePtr = POINTER TO Node;
  Node = RECORD
              x, y : CARDINAL;
              next : NodePtr;
            END;

VAR
  a, b, c : ARRAY [0..255] OF CARDINAL;
  M       : ARRAY [0..99], [0..99] OF CARDINAL;
  m       : CARDINAL;
  head    : NodePtr;

  PROCEDURE Test(ch : CHAR);
  VAR
    i, j, k : CARDINAL;
    p : NodePtr;

    PROCEDURE P;
    BEGIN
    END P;

    PROCEDURE Q(x, y, z, w : CARDINAL);
    BEGIN
    END Q;

  BEGIN
    CASE ch OF
      (*----- Loops -----*)
      'a' : (* Empty REPEAT loop *)
         k := 20000;
         REPEAT
               k := k - 1;
         UNTIL k = 0 |

      'b' : (* Empty WHILE loop *)
         i := 20000;
         WHILE i > 0 DO
            i := i - 1;
         END |

      'c' : (* Empty FOR loop *)
         FOR i := 1 TO 20000 DO
         END |
      (*----- Cardinal Arithmetic -----*)
      'd' : (* CARDINAL arithmetic *)
         j := 0;
         k := 10000;
         REPEAT
            k := k - 1;
            j := j + 1;
            i := (k * 3) DIV (j * 5);
         UNTIL k = 0 |

      (*----- Array Indexing -----*)
      'e' : (* Array of single dimension *)
         k := 20000;
         i := 0;
         b[0] := 73;
         REPEAT
            a[i] := b[i];
            b[i] := a[i];
            k := k - 1;
         UNTIL k = 0 |
```



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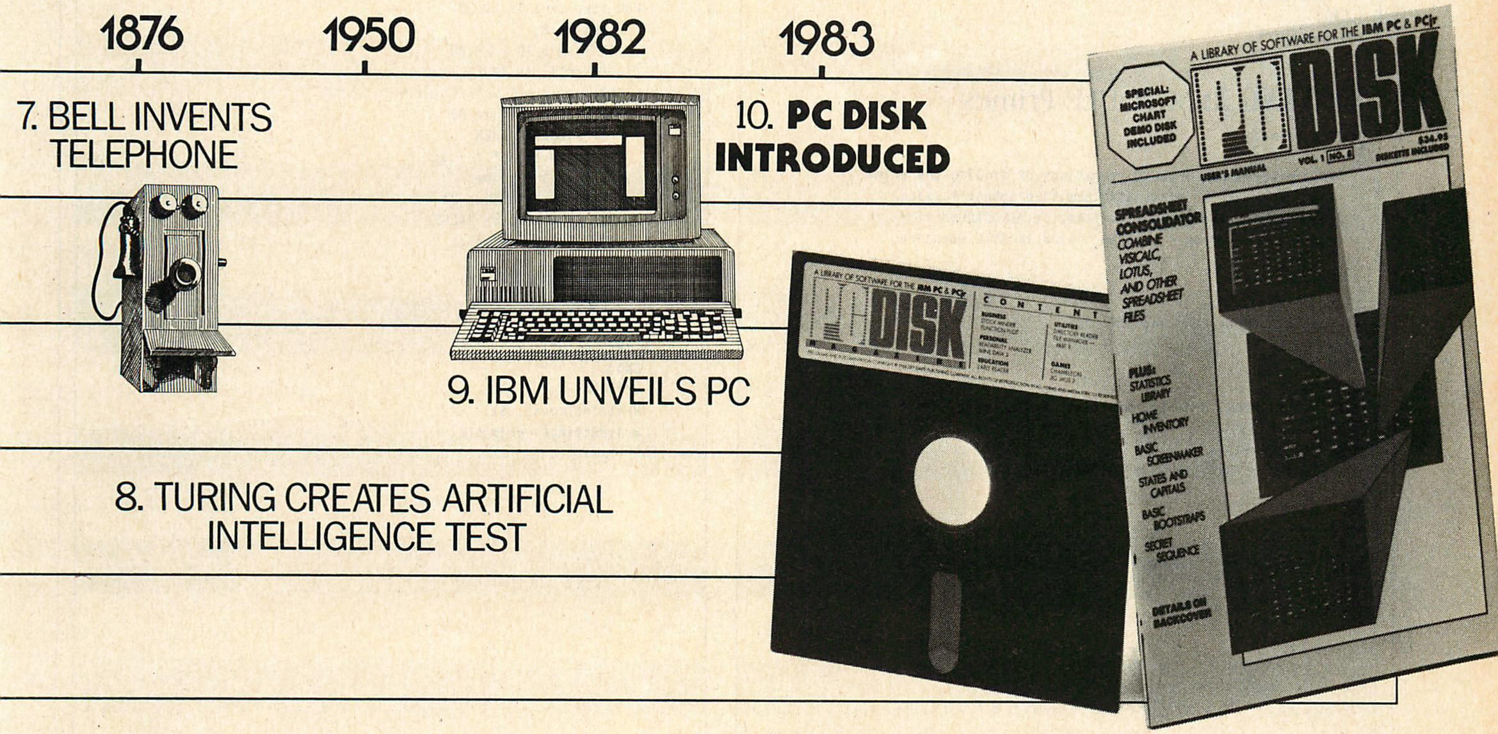
```
'f' : (* Two-dimensional array *)
      FOR i := 0 TO 99 DO
        FOR j := 0 TO 99 DO
          M[i, j] := M[j, i];
        END;
      END |

(*----- Procedure Calls -----*)
'g' : (* Call of empty, parameterless procedure *)
      k := 20000;
      REPEAT
        P;
        k := k - 1;
      UNTIL k = 0 |

'h' : (* Call of empty procedure with four parameters *)
      k := 20000;
      REPEAT
        Q(i, j, k, m);
        k := k - 1;
      UNTIL k = 0 |

(*----- Block Move -----*)
'i' : (* Copying arrays (block moves) *)
      k := 500;
      REPEAT
        k := k - 1;
        a := b;
        b := c;
        c := a;
      UNTIL k = 0 |

'j' : (* Pointer chaining *)
      k := 500;
      REPEAT
        p := head;
```

```
        REPEAT
          p := p^.next;
        UNTIL p = NIL;
        k := k - 1;
      UNTIL k = 0
    END;

  END Test;

VAR
  ch      : CHAR;
  n       : CARDINAL;
  q       : NodePtr;

BEGIN (* of MODULE Benchmark *)

  head := NIL;
  n := 100;
  REPEAT  (* initialize list *)
    q := head;
    NEW(head);
    head^.next := q;
    n := n - 1;
  UNTIL n = 0;

  Write('>');
  Read(ch);
  WHILE ('a' <= ch) & (ch <= 'j') DO
    Write(ch);
    WriteLn;
    n := 0;
    REPEAT
      n := n + 1;
      Test(ch); (* call the test routine *)
      IF (n MOD 50) = 0 THEN
        WriteLn;
      END;
      Write('.');
```



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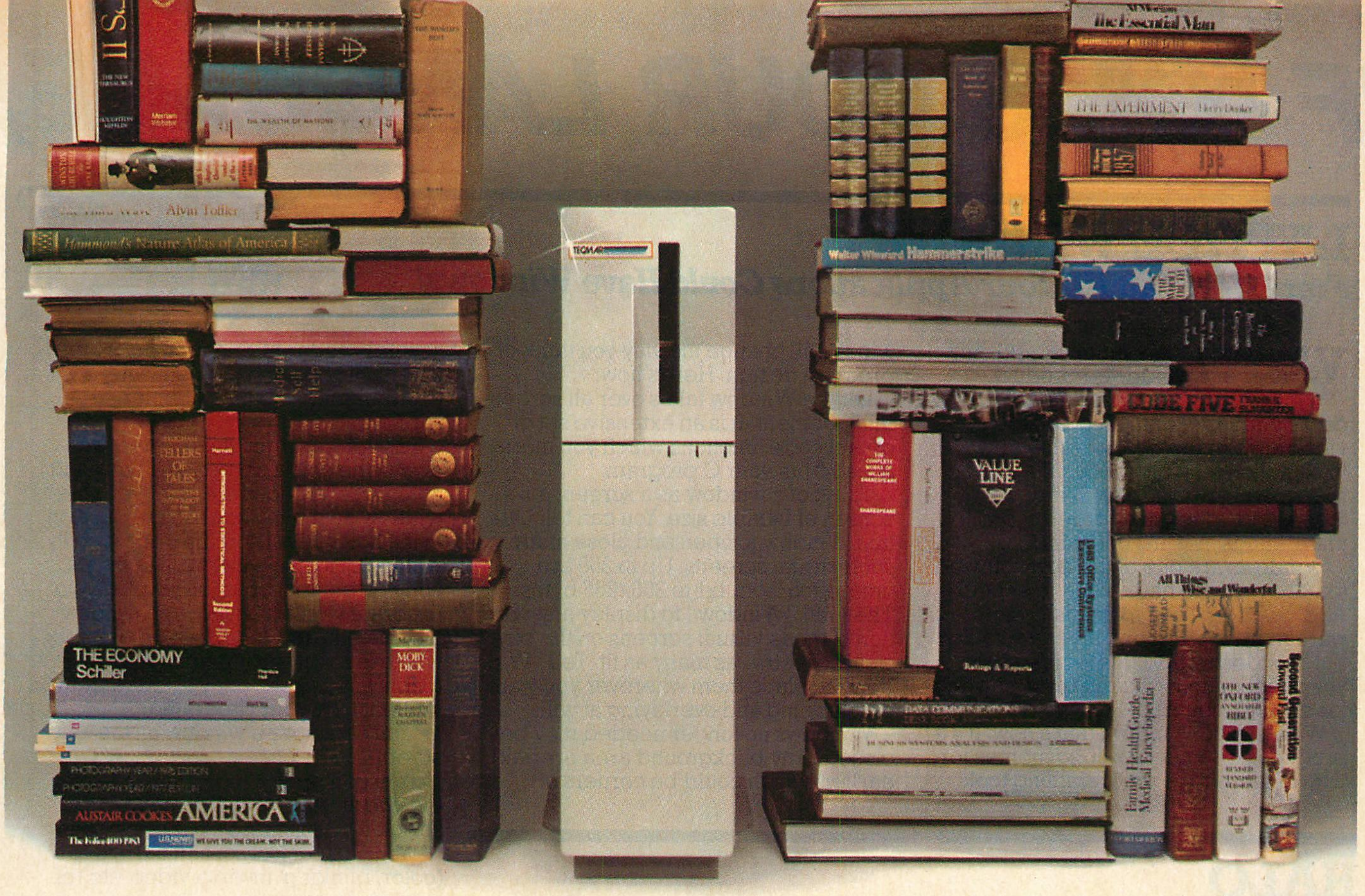
```
    UNTIL n = 100;
    WriteLn;
    Write('>');
    Read(ch);
  END;
END Benchmark.
```

LISTING 2: MODULE Primes

```
MODULE Primes;
(*
   This program performs 10 iterations of finding the prime
   numbers among the first 8190 positive integers using
   the Eratosthenes Sieve algorithm. It is adapted with
   minor changes from a program listed in BYTE magazine,
   January 1983.
*)

(* Turn all error checking off: *)
(*$R-*)
(*$S-*)
(*$T-*)
FROM InOut IMPORT WriteLn, WriteInt, WriteString, Write;

CONST Size = 8190;
VAR   Flags : ARRAY[0..Size] OF BOOLEAN;
      i, prime, k, count, iter : CARDINAL;
BEGIN
  WriteString("10 iterations");
  WriteLn;
  FOR iter := 1 TO 10 DO
    count := 0;
    FOR i := 0 TO Size DO
      Flags[i] := TRUE;
    END;
    FOR i := 0 TO Size DO
      IF Flags[i] THEN
        prime := i * 2 + 3;
        k := i + prime;
        WHILE k <= Size DO
          Flags[k] := FALSE;
          INC(k, prime);
        END;
        INC(count);
      END;
    END;
    Write(".");
  END;
  WriteLn;
  WriteInt(count, 6);
  WriteString(" primes");
END Primes.
```



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Significant Figures, III

Routines for binary-to-decimal floating-point conversion on the IBM PC

ROBERT GRAY

The usefulness of the routines for floating-point addition, subtraction, multiplication, and division that appeared in the first two parts of this article ("Significant Figures, I," October 1984, page 54, and "Significant Figures, II," November 1984, page 171) is somewhat limited by the lack of provision in the routines for numeric input and output. This article presents routines for converting numbers from ASCII decimal to binary floating-point format and vice versa.

FROM ASCII DECIMAL TO BINARY FLOATING-POINT FORMAT

Converting an ASCII decimal number to its binary floating-point equivalent requires two subroutines that perform operations on the two parts of a floating-point number: the mantissa and the exponent. (In the number 123E-2, for example, the mantissa is 123, and the exponent is -2. To interpret this number, multiply the mantissa by 10 raised to the exponent power—123E-2 $= 123 * 10^{-2} = 1.23$.) One of these subroutines converts the mantissa and exponent parts to their binary equivalents, and the other forms powers of 10.

First Subroutine: Converting the Mantissa and Exponent to Their Binary Equivalents. The conversion subroutine can be simplified by treating both the mantissa and the exponent as integers, so that the same routine can be used to convert both. Most assembly language programmers will be familiar already with the algorithm that is used for converting an ASCII integer to its binary equivalent. That algorithm can be adapted slightly for use here.

One adaptation will be necessary because the mantissa may well exceed the capacity of a single 16-bit word (65,535 is the largest number representable in 16 bits); the conversion routine will thus have to build a double-word binary integer. The routine given earlier for double-word multiplication (see "Significant Figures, II," November 1984, page 171) can be used.

It is also necessary to account for the decimal point somehow. The simplest option here is to treat all of the digits as forming a single integer and to count the number of places following the decimal point. This effectively converts the original mantissa to a floating-point number whose exponent is the count of the number of decimal places, expressed as a negative number. The result may then be adjusted by subtracting this number from the original exponent. For example, 11.5E+3 becomes 115E+3−1 = 115E+2 = 11,500.

Robert Gray is an assistant professor of information systems at Virginia Commonwealth University.

The following algorithm, which uses a clever trick for counting the decimal places, can be used to convert an ASCII decimal integer to binary form:

1. Initialize COUNT, the number of decimal places, to some large positive number and initialize B, the binary integer, to zero
2. S = ASCII sign
3. Repeat 3.1 and 3.2 for each ASCII digit:
   3.1 T = next ASCII digit
   3.2 IF T is a decimal point THEN
       COUNT = 0
       ELSE
          B = B * 10 (shift current result left one decimal place)
          T = T − 48
          B = B + T (add in this digit)
          COUNT = COUNT − 1
          IF B > maximum integer THEN set error flag and return
4. IF S = negative THEN B = 0 − B (negate the result if sign was negative)
5. IF COUNT > 0 THEN COUNT = 0 (set count to zero if number contains no decimal places)

Because COUNT is decremented each time an integer is found, and it is set to zero only when a decimal point is located, it will be positive if the number contains no decimal point (thus, it is set to zero, as shown above in step 5). Otherwise, it will hold the number of decimal places as a negative number.

Listing 1 implements this algorithm as a general-purpose 32-bit conversion routine called BIN32. Note that this routine will return an error (a nonzero value in BX) if the input integer exceeds 2^{31}. Because this routine is used to convert an ASCII mantissa, the range of acceptable mantissas is limited to between 9 and 10 decimal digits. Larger numbers will have to be entered in floating-point format.

Second Subroutine: Forming Powers of 10. Converting the exponent part of a decimal floating-point number requires that 10 be raised to the power specified by the exponent. For positive exponents, the exponent could simply be multiplied by itself the required number of times,

Converting the exponent part of a decimal floating-point number requires that 10 be raised to the power of the exponent.

as in the following example:
E+5 = 10 * 10 * 10 * 10 * 10.

But the same result can be obtained with fewer calls to the multiplication routines by using the intermediate products. Using the same example then, 10^5 can be computed with only three multiplications: $10^5 = 10^2 * 10^2 * 10$. Here one multiplication is required to generate 10^2; multiplying that by itself yields 10^4; and multiplying that by 10 yields 10^5. This technique is known as the binary method, and the trick lies in knowing when to multiply and when to square.

D. E. Knuth, in the *Art of Computer Programming*, vol. 2 (Reading, MA: Addison-Wesley, 1973), gives the following algorithm for raising a binary number to a positive integer power:

1. Let X be the binary number and E be the positive integer exponent
2. N = E: Z = X
3. N = N/2 (Shift N to the right one place)
4. IF N was odd (shifting produced a carry) THEN Y = Y * Z
   IF N = 0 THEN GOTO STEP 7 (if N is 0 the algorithm terminates with the result in Y; otherwise square Z)
5. Z = Z * Z
6. GOTO STEP 3
7. EXIT

Adapting this algorithm for use with a negative integer exponent is fairly simple. Because a number raised to a negative power is the reciprocal of the number raised to the same positive power, steps 2 and 7 need to be modified as follows:

2. N = ABS(E): Z = X
7. IF E < 0 THEN Y = 1/Y

Listing 2 implements this algorithm as a general-purpose routine, called IPOWER_F. The routine is used for raising a floating-point number to a 16-bit integer power.

These subroutines can now be put to use in a routine for converting an ASCII decimal number to binary floating-point format. The algorithm used here is from Jerome Coonen's article, "An Implementation Guide to a Proposed Standard for Floating-Point Arithmetic" (*Computer*, January 1980, page 68).

1. Let M be the ASCII string, with mantissa MA, sign SMA, and exponent EA; and let F be the resulting binary floating-point number with biased exponent EF, 24-bit mantissa MF, and sign SF.
2. CALL BIN32(T,COUNT,MA) (convert MA to 32-bit binary integer T, with number of decimal places in COUNT)
3. IF T = 0 THEN F = 0: EXIT (if the ASCII mantissa is zero, set the result to zero and exit)
4. EF = 32 + bias (binary point initially follows bit 0 in T)
5. WHILE most significant bit in T is 0 (normalize T)
   Shift T left 1
   EF = EF − 1 (decrement exponent)
6. MF = T (store T as a 24-bit mantissa in MF)
7. CALL BIN32(T,COUNT,EA) (convert ASCII exponent EA to integer T)
8. T = T + COUNT (adjust exponent for decimal places)
9. IF T <> 0 THEN CALL IPOWER_F(F,T) (if exponent T

is nonzero, raise the floating-point number F to the power T)

9. SF = SMA (set result sign)

As this routine is implemented in listing 3, it is not necessary to enter an exponent; thus, it is possible to enter either .999 or 999E-3. If no exponent is entered, it will exit after step 6 in the algorithm.

It should also be noted that this routine, like those that follow, uses two intermediate data areas, called IM1 and IM2, for passing data to other routines. These two variables should both be declared as double words. For example,

```
DATA SEGMENT
        IM1  DW
        IM2  DW
DATA ENDS
```

They do not need to be initialized.

FROM BINARY FLOATING-POINT TO ASCII DECIMAL

Converting from ASCII decimal to binary floating-point format is not an easy task; developing a routine to convert binary floating-point numbers to ASCII decimal format is even more challenging.

This conversion is a two-step process. In the first step, the binary exponent and mantissa are converted to integers in the proper range—for example, the binary exponent is converted to an integer in the range −38 to +38. These integers then may be converted directly to ASCII decimal numbers.

The second step, converting a binary integer to ASCII format, is simpler than the first. The range of exponent values is small enough that the exponent may be stored in a single 16-bit word, and the algorithm for converting a 16-bit binary value to ASCII format may be familiar to assembly language programmers. It consists essentially of successively dividing the binary value by 10, using the remainder in each case to form the ASCII digits:

1. Let B be the binary integer.
2. IF B < 0 THEN S = "−": B = ABS(B) (Save sign of B. If B is negative, make it positive) ELSE S = "+"
3. Q = B
4. Divide Q by decimal 10, yielding a new quotient, Q, and a remainder, R
5. R = R + 48 (Convert R to ASCII decimal form)
6. Add ASCII digit R to front of ASCII string
7. REPEAT steps 3–6 UNTIL Q = 0
8. Add sign S to front of ASCII string

The routine in listing 4 shows one implementation of this algorithm.

Converting the mantissa is just slightly more difficult, because, in most cases, it will be a double-word integer. Converting a double-word integer to ASCII decimal form poses only one difficulty: dividing a 32-bit integer by ten is likely to cause overflow. This can be avoided by breaking the original 32-bit integer into parts, no one of which exceeds the capacity of a single 16-bit word.

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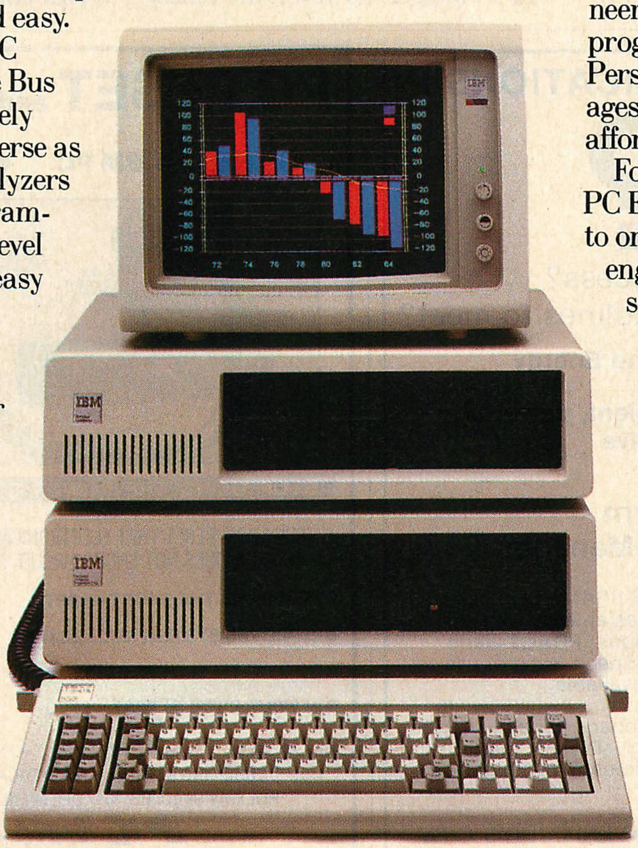

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In this case, because the mantissa will not actually exceed 24 bits, it is possible to divide by decimal 10,000. This divides the mantissa into two parts in the range 0–9,999; each of these parts may be converted using the 16-bit conversion routine. An assembly language routine, ASC32, that illustrates this process is in listing 5.

Actually, it would be possible to simplify the floating-point routines somewhat so that the same routine could be used to convert both the one-word exponent and the double-word mantissa. A second routine for conversion from double-word binary to ASCII decimal form is given here simply to make the routines more widely usable.

Before the routines that convert binary numbers to ASCII decimal can be used, the exponent and mantissa must be obtained as integers in the proper range. This is done by obtaining an integer exponent and a floating-point number representing the ASCII mantissa. This number is converted to an integer, which may be converted to ASCII.

Converting a floating-point number to an integer is also fairly simple, provided that it is in the proper range. In the floating-point format used here (which is the same as that used by IBM PC BASIC), the decimal number 10.75 would look like that shown in figure 1.

Restoring the sign bit changes it to a binary 1. The binary point is implicit; its position is indicated by the exponent, which, when the bias of 128 (1000 0000) is removed, turns out to be 4. Making the binary point explicit, the mantissa, is 1010.1100 0000 0000 0000 0000 or 10.75.

Of course, the number will not interpret in quite this way in the 8088, because there is no way to represent an explicit binary point. In an integer, however, the binary point is assumed to follow the least significant digit, so to convert this number to an integer it is necessary only to shift it to the right 20 (24 minus the exponent) bits, until the binary point follows the least significant bit. The bits following the binary point can be shifted into the upper bits of the following word and treated as a binary fraction.

Shifting in this way would yield a number that looks like figure 2 (note, the binary point is shown only for the sake of illustration).

If the fraction in word two is simply dropped, the original floating-point number, 10.75, will be truncated to 10. The number 10.75 is much closer to 11 than to 10, however, and, in most cases, it would be preferable to use the fraction in word two to round the integer.

Ordinarily, decimal numbers are rounded by adding .5 to the most significant digit of the fraction. That could be done in this case

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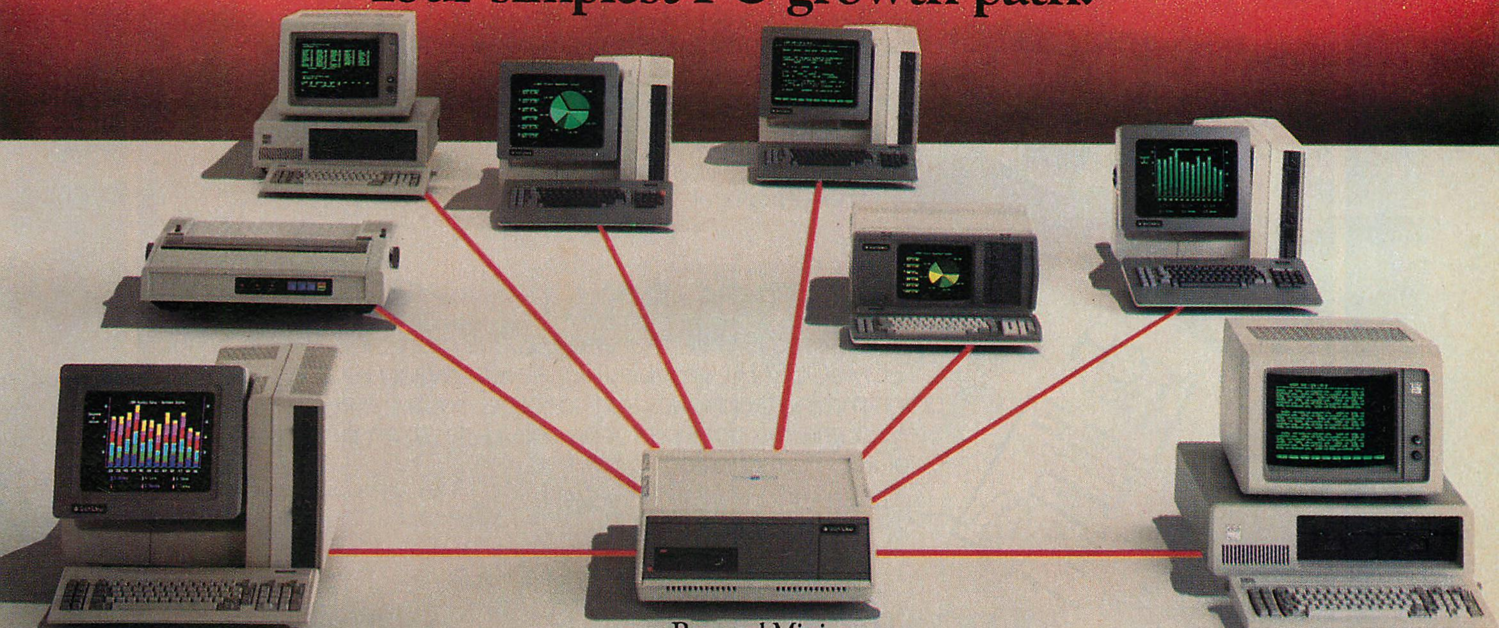

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simply by shifting word two left and adding the carry (the bit shifted out) to word one. Unfortunately, this technique, simple as it is, introduces an undesirable bias. An alternative is to round to the nearest even number, rounding up, when word one is even, only if the fraction is greater than .5 and, when word one is odd, only if word two is greater than or equal to .5.

The best way to convert a floating-point number to an integer is sometimes by truncation and sometimes by rounding to the nearest even number, so routines are provided that do both. Routine RN__F (listing 6) rounds a floating-point number to the nearest even integer value by first converting the number to an integer using the technique just described, rounding to the nearest even number, and then converting the integer portion back into floating-point notation.

As it is implemented in listing 7, routine INT__F first calls RN__F to round the number to an integer value and then converts the result to a 32-bit integer by truncation. This call may be removed to provide a routine for direct integer conversion. (Input to INT__F, in that case, would be directly through the register pair DX:AX.)

These routines provide a basis for a routine that converts binary numbers to ASCII floating-point. The following algorithm is an adaptation of one developed by Coonen (see the article mentioned earlier).

1. Let X be the binary floating-point number with biased exponent E
2. S = sign of X (save the sign of X in S)
3. X = ABS(X) (restore leading 1)
4. Compute U = Log base 10 of X. This is approximately equal to log base 2 of X times log base 10 of 2 or to the unbiased exponent minus 1 times .3. This step thus becomes U = E-1 * .3
5. V = U + 1 − k (compute decimal exponent V. K is number of places to be displayed in the mantissa—7 in this case)
6. F = 10: CALL IPOWER__F(F,V) (compute 10^v)
7. W = X/F (dividing X by 10^v will yield a result that may be converted into a K-digit ASCII integer)
8. IF W >= 10^k THEN V = V + 1: GOTO 5 (adjust W. If it would contain more than K decimal digits, increment V and adjust W downward)
9. IF W <= $10^{(K-1)} - 1$ THEN V = V − 1: GOTO 5 (If it would contain too few digits, decrement the decimal exponent V and adjust W upward)
10. CALL ASC16(V) (convert integer exponent to ASCII decimal)
11. Restore sign S to W
12. CALL INT__F(W) (convert floating-point W to 32-bit integer)
13. CALL ASC32(W) (convert 32-bit integer W to ASCII decimal)

Much of the work done in this algorithm is intended to produce a standardized ASCII-decimal mantissa containing seven decimal digits followed by an implied decimal point. The number 1, for example, would be converted to 1000000E-6.

As it appears in listing 8, the algorithm has been modified slightly. Steps 5 and 9 can both produce a value in V of less than −38 decimal. This would cause the exponentiation routine IPOWER__F to underflow, that is, to produce a value too small to be represented as a normalized floating-point number in floating-point format. In those cases, the algorithm in listing 8 sets the exponent to its minimum valid value. This will occasionally result in an ASCII mantissa containing fewer than seven digits.

The routines presented in this series of articles have been developed primarily to illustrate floating-point techniques, and they are not guaranteed in any way. Although they may occasionally generate round-off errors (for example, .9999999 may be rounded off to 1000000E-6), they are accurate, for the most part, to about six places.

The set of floating-point routines presented here is not complete. Routines for comparing floating-point numbers and for finding square roots and remainders are not included. The routines that have been presented, however, cover the basic arithmetic functions and may, therefore, help in developing a more complete library.

FIGURE 1: *The Decimal Number 10.75 in Floating-point Notation*

	BIASED EXPONENT	SIGN BIT	23-BIT MANTISSA
BINARY	10000100	0	010 1100 0000 0000 0000 0000
HEX	84		2C 00 00

FIGURE 2: *The Binary Number 10.75 in Integer Form*

WORD 1	WORD 2
0000 0000 0000 1010.	1100 0000 0000 0000

ERRATA

"Significant Figures, I" in the October 1984 issue contained some errors. In figure 5, the topmost arrow labeled guard bit *should point to the first of the three bits that have been shifted out. In the same figure, a 1 that is shown being added to the sticky bit in the bottom group of numbers should be shifted to the left one place. On page 61 it is stated that the floating-point addition and subtraction routine returns its results in registers AX:DX. Results are returned in DX:AX.* —WF

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LISTING 1: BIN32.ASM

```
BIN32   PROC    NEAR
;**************************************************************
;               converts an ASCII decimal string to a
;               signed 32-bit binary integer in DX:AX
;               input--DI points to end of string
;                      SI points to start
;               output--CX if negative, number of digits
;                       right of decimal point
;                       SI points to next unconverted char
;**************************************************************
        PUSH    BP
        SUB     DX,DX
;                       get sign
        MOV     CX,DX           ;assume positive sign
        MOV     AL,[SI]         ;put first char in AL
        CMP     AL," "          ;is it blank? positive sign
        JE      BIN32A
        CMP     AL,"+"          ;is it plus sign?
        JE      BIN32A
        CMP     AL,"-"          ;is it minus sign?
        JNE     BIN32B
        DEC     CX              ;sign negative-set flag in CX
BIN32A: INC     SI              ;point to next char
BIN32B: PUSH    CX              ;save sign
;                       convert string
        MOV     AX,DX           ;0-initial NUMber in DX:AX
        MOV     CL,127          ;max 127 places left of decimal
                                ;CL=COUNT places right of decimal
;                       get ASCII digit
BIN32C: MOV     CH,[SI]         ;next char in CH
        CMP     CH,"9"          ;if CH > "9" not a digit
        JA      BIN32H
        SUB     CH,48           ;convert to binary
        JB      BIN32H          ;if CH < "0" not a digit
        DEC     CL              ;found digit--decrement COUNT
;                       multiply NUM * 10
        MOV     BP,CX           ;save CX in BP
        SUB     CX,CX           ;decimal 10 in CX:BX
        MOV     BX,10
        CALL    MUL32           ;MUL32 returns DX:AX:CX:BX
;                       check for overflow--over 2^31-1
        OR      AX,AX           ;if AL not zero, product
        JNZ     BIN32I          ;is > or = 2^32-overflow
        OR      CX,CX           ;if CX sign bit set, product
        JS      BIN32I          ;is > or = 2^31-overflow
;                       add in this digit
        XCHG    CX,BP           ;digit & COUNT in CX
        MOV     AL,CH           ;this digit in DX:AX
        ADD     AX,BX           ;add NUM*10 from CX:BX
        ADC     DX,BP
        JC      BIN32I          ;check for overflow again
;                       get next ASCII character
BIN32D: INC     SI              ;point to next char
        CMP     SI,DI           ;is there another one?
        JB      BIN32C          ;if so, go get it
;                       set final decimal place count
BIN32E: XCHG    AX,CX           ;convert count in CL
        CBW                     ;to word in AX
        XCHG    AX,CX           ;put count back in CX
        OR      CX,CX           ;there are no decimals
        JS      BIN32F          ;if count in CX is positive,
        SUB     CX,CX           ;so make CX zero
;                       restore sign
BIN32F: POP     BX
        OR      BX,BX
        JNS     BIN32G          ;if sign was negative
        NOT     AX              ;negate NUM
        NOT     DX
        ADD     AX,1
        ADC     DX,0
;                       wrap up
BIN32G: SUB     BX,BX           ;BX=0  status ok
        POP     BP
        RET
;                       found non-numeric character
BIN32H: CMP     CH,-2           ;is it decimal point (46-48)?
        JNE     BIN32E          ;if not, finish
        SUB     CL,CL           ;decimal so,set COUNT to zero
        JMP     BIN32D          ;and get next char
;                       overflow
BIN32I: POP     BX              ;remove sign from stack
        POP     BP              ;restore BP
        MOV     BX,1            ;BX=1 overflow flag
        RET
BIN32   ENDP
```

LISTING 2: IPOWER_F.ASM

```
IPOWER_F PROC   NEAR
;**************************************************************
;               raises floating point mantissa pointed
;               by DI to 16 bit integer exponent pointed
;               to by SI
;**************************************************************
        PUSH    SI
        PUSH    DI
        SUB     AX,AX           ;clear registers
        MOV     CX,AX
;                       get mantissa
        MOV     BX,[DI]         ;f.p. mantissa in CX:BX
        OR      CX,[DI]+2
        JNZ     E0      ;check for zero mantissa
        SUB     DX,DX           ;set result in DX:AX
        MOV     AX,DX           ;to zero
        JMP     EXIT            ;and return
;                       get result sign
E0:     MOV     DX,0080h        ;isolate sign
        AND     DX,CX           ;in DX
        PUSH    DX              ;and save it
;                       get exponent
        MOV     DI,AX           ;clear DI
        OR      DI,[SI]         ;OR  exponent into DI
        MOV     SI,DI           ;save it temporarily in DI
        JS      E1              ;jump if negative exponent
        JNZ     E2      ;check for zero exponent
        MOV     DX,8100H        ;zero--set result to 1
        MOV     AX,0
        POP     CX              ;get sign
        OR      DX,CX           ;and restore it
        JMP     EXIT            ;and return
;
E1:     NEG     DI              ;make exponent positive
;
E2:     MOV     IM1,AX          ;store Y--initially = +1
        MOV     IM1+2,8100H
        MOV     IM2,BX          ;store Z
        MOV     IM2+2,CX
;
        PUSH    SI              ;save original exponent
;
E3:     SHR     DI,1            ;N=N/2
        JNC     E4              ;jump if N was even
;                       compute Y=Z*Y
        PUSH    DI              ;save N
        MOV     SI, OFFSET IM1  ;address of Y in SI
        MOV     DI, OFFSET IM2  ;address of Z in DI
        CALL    MUL_F           ;Y=Y*Z--product in DX:AX
        OR      BX,BX           ;check completion status
        JNZ     E8              ;jump if error
        MOV     IM1,AX          ;store Y
        MOV     IM1+2,DX
;                       if N=0 then quit
        POP     DI              ;get exponent
        OR      DI,DI
        JZ      E5
;                       compute Z*Z
E4:     PUSH    DI              ;save N
        MOV     SI, OFFSET IM2  ;address of Z in SI
        MOV     DI,SI           ;and in DI
        CALL    MUL_F           ;Z*Z--product in DX:AX
        OR      BX,BX           ;check completion status
        JNZ     E8
        MOV     IM2,AX          ;store Z
        MOV     IM2+2,DX
        POP     DI
;
        JMP     E3              ;repeat for next N
```

```
;                           compute reciprocal if
E5:       POP       CX                ;original exponent
          OR        CX,CX
          JNS       E6                ;was negative
          MOV       DX,8100H          ;set up dividend of 1
          SUB       AX,AX
          MOV       IM2,AX            ;put it in IM2
          MOV       IM2+2,DX
          MOV       SI, OFFSET IM1
          MOV       DI, OFFSET IM2
          CALL      DIV_F             ;reciprocal in DX:AX
          OR        BX,BX             ;check completion code
          JNZ       E9
;                           set result sign
E6:       POP       DI
          OR        DX,DI
          JMP       EXIT

;                           here if error
E8:       POP       DI                ;pop stack
          POP       DI
E9:       POP       DI
          JMP       EXIT              ;and return
IPOWER_F ENDP
```

LISTING 3: BIN__F.ASM

```
BIN_F     PROC      NEAR
;************************************************************
;                   converts an ASCII decimal number to
;                   binary floating point
;                   Input--DI points to points to end of ASCII
;                          string; SI points to start
;************************************************************
          PUSH      SI
          PUSH      DI
;                        convert ASCII mantissa to integer
          CALL      BIN32           ;integer in DX:AX
          OR        BX,BX           ;did it convert OK?
          JZ        BINF1           ;if error
          JMP       BINF9           ;jump
;                        check for zero result
BINF1:    MOV       BX,DX
          OR        BX,AX
          JNZ       BINF2           ;finished if zero
          JMP       BINF8
;                        get sign
BINF2:    PUSH      CX              ;save count of decimal places
          SUB       CX,CX           ;assume positive sign
          OR        DX,DX
          JNS       BINF3
          DEC       CX              ;negative sign
          NOT       AX              ;make it positive
          NOT       DX
          ADD       AX,1
          ADC       DX,0
;                        convert 32-bit integer to f.p
BINF3:    MOV       BX,152          ;initial exponent=24+bias
          OR        DH,DH           ;if DH
          JZ        BINF4           ;is not zero
          XCHG      AH,AL           ;shift right 8 bits
          XCHG      DL,AH
          XCHG      DH,DL           ;integer now in DL:AX:DH
          ADD       BX,8            ;increment exponent
;                        normalize
BINF4:    OR        DL,DL
          JS        BINF5           ;if no sign bit
          SHL       DH,1            ;shift integer left
          RCL       AX,1
          RCL       DL,1
          DEC       BX              ;and decrement exponent
          JMP       BINF4
BINF5:    MOV       DH,BL           ;exponent in DH
;                        ;restore sign
          OR        CX,CX
          JNZ       BINF6
          AND       DL,07FH         ;make sign positive
BINF6:    PUSH      AX              ;save result--ASCII mantissa
```

```
        PUSH    DX
;                       check for exponent
        SUB     AX,AX           ;zero exponent
        MOV     DX,AX
        CMP     SI,DI           ;if at end of ASCII string
        JAE     BINF7           ;no ASCII exponent
        MOV     BL,[SI]         ;next unconverted char in BL
        OR      BL,32           ;convert to lower case
        CMP     BL,"e"          ;if not an "E"
        JNE     BINF7           ;there is no exponent
;                       convert exponent
        INC     SI              ;point to next char
        CALL    BIN32           ;convert exponent to binary
        OR      BX,BX           ;check for error
        JNZ     BINF9
;                       check exponent range
        OR      DX,DX           ;DX should be zero if exponent
        JZ      BINF7           ;positive and less than 2^16
        CMP     DX,-1           ;or -1 if negative
        JNE     BINF9           ;jump if out of range
;                       apply exponent to mantissa
BINF7:  MOV     BX,AX           ;signed exponent in BX
        POP     DX              ;retrieve mantissa in DX:AX
        POP     AX
        POP     CX              ;count of decimal places
        ADD     BX,CX           ;subtract decimal places
        JZ      BINF8           ;finished if exponent is zero
;                       compute exponent power of 10
        PUSH    AX              ;save mantissa while we
        PUSH    DX              ;compute exponent
        MOV     IM2,BX          ;integer exponent in IM2
        MOV     SI,OFFSET IM2   ;address in SI
        MOV     IM1,0           ;floating point 10
        MOV     IM1+2,8420H     ;in IM1
        MOV     DI,OFFSET IM1   ;address in DI
        CALL    IPOWER_F        ;compute exponent
        POP     [DI]+2          ;retrieve mantissa and
        POP     [DI]            ;put it in IM1
        OR      BX,BX           ;check for errors
        JNZ     BINF9
        MOV     IM2,AX          ;put exponent in IM2
        MOV     IM2+2,DX
;                       multiply mantissa x exponent
        CALL    MUL_F
        OR      BX,BX           ;check for errors
        JNZ     BINF9
;                       exit with result in DX:AX
BINF8:  SUB     BX,BX           ;BX=0--status OK
        JMP     EXIT
BINF9:  MOV     BX,1            ;exit with error
        JMP     EXIT
BIN_F   ENDP
```

LISTING 4: ASC16.ASM

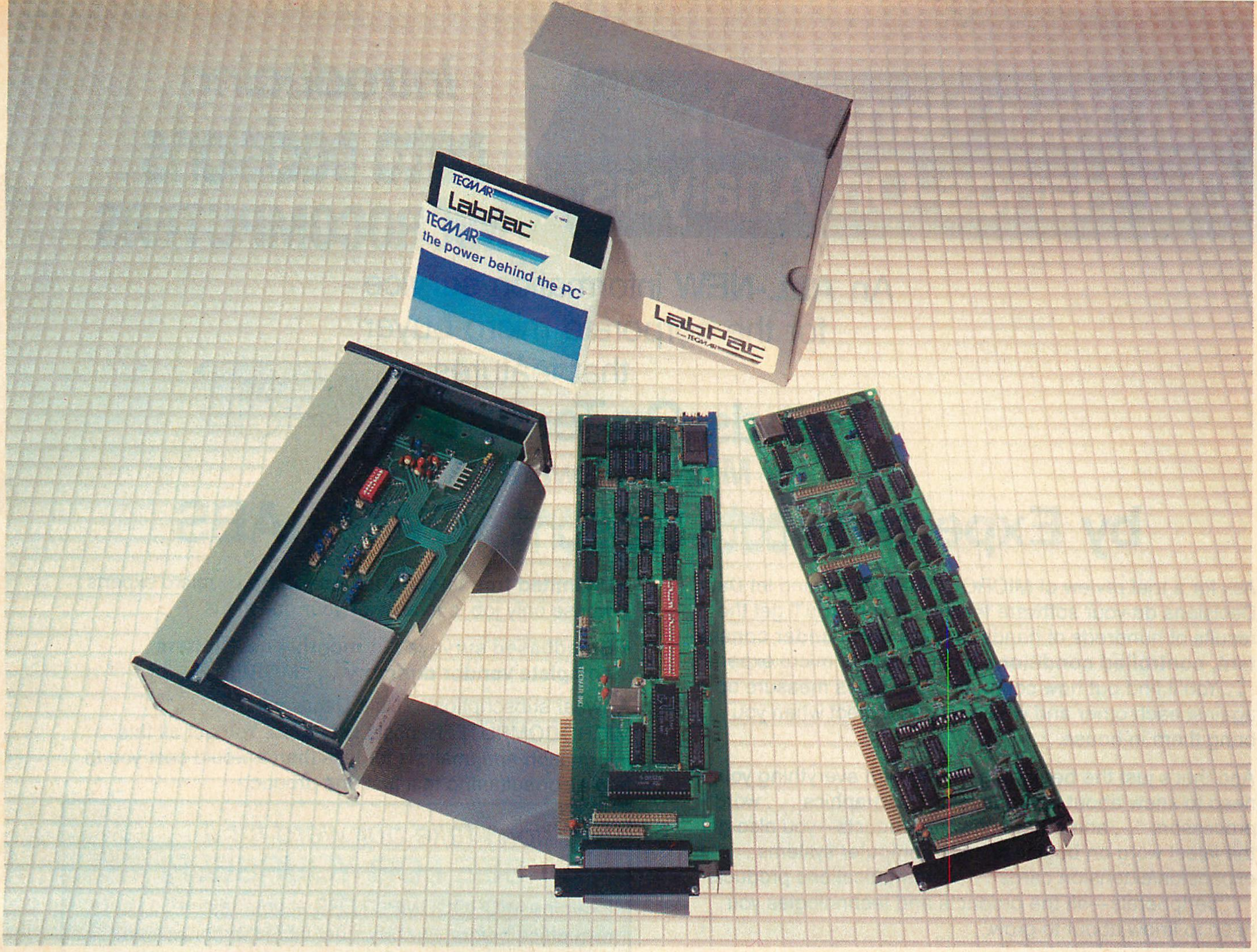
```
ASC16   PROC    NEAR
;*****************************************************************
;               Converts a 16-bit signed integer to ASCII
;               SI offset to integer; DI to last byte of
;               ASCII location. BX returns offset to first
;               character (sign) of ASCII value
;*****************************************************************
        PUSH    SI
        SUB     AX,AX           ;clear AX
        OR      AX,[SI]         ;get binary integer
;                       check sign
        MOV     SI," "          ;assume sign positive
        JNS     ASC16A
        MOV     SI,"-"          ;save negative sign
        NEG     AX              ;and make integer positive
;                       convert to ASCII decimal
ASC16A: MOV     BX,DI           ;initial offset in BX
        MOV     CX,10           ;decimal 10 in CX
ASC16B: SUB     DX,DX           ;clear DX
        DIV     CX              ;divide by 10
        ADD     DX,48           ;convert remainder to ASCII
        MOV     [BX],DL         ;save it
        DEC     BX              ;point to next position
        OR      AX,AX           ;if quotient is not zero
        JNZ     ASC16B          ;do it again
;                       set sign
        MOV     AX,SI           ;sign in AL
        MOV     [BX],AL         ;save it
;
        POP     SI
        RET
ASC16   ENDP
```

LISTING 5: ASC32.ASM

```
ASC32   PROC    NEAR
;*************************************************************
;               Converts a 32-bit signed integer to ASCII
;               SI points to integer; DI to ASCII last byte
;               in ASCII location. BX returns offset to
;               first character (sign)
;*************************************************************
        PUSH    SI
        PUSH    DI
        SUB     DX,DX           ;clear DX & BX
        MOV     BX,DX
        MOV     AX,[SI]         ;get integer
        OR      DX,[SI]+2
;                       check sign
        MOV     SI," "          ;assume positive sign
        JNS     ASC32A          ;if number negative
        NOT     AX              ;make it positive
        NOT     DX
        ADD     AX,1
        ADC     DX,0
        MOV     SI,"-"          ;and set negative sign
;
ASC32A: PUSH    SI              ;save sign
;                       break into two 3-4 digit integers
        MOV     BX,10000        ;decimal 10,000 in BX
        DIV     BX              ;divide integer by 10,000
;
        PUSH    AX              ;quotient--first 3 ASCII digits
        MOV     SI,OFFSET IM1   ;SI points to positive integer
        MOV     IM1,DX          ;remainder in range 0-9,999
        CALL    ASC16           ;convert remainder to ASCII
;                       check for zero quotient
        POP     AX              ;get the quotient
        OR      AX,AX
        JZ      ASC32D          ;finished if it is zero
;                       adjust ASCII remainder
        MOV     CX,BX           ;pointer to ASCII sign in CX
        SUB     CX,DI           ;CX is count of ASCII digits
        ADD     CX,4            ;should be 4
        JZ      ASC32C          ;if it isn't
ASC32B: MOV BYTE PTR [BX],"0"   ;fill it out with zeros
        DEC     BX
        LOOP    ASC32B
;                       convert quotient
ASC32C: MOV     DI,BX           ;DI points to next position
        MOV     SI,OFFSET IM1   ;SI points to location of
        MOV     IM1,AX          ;quotient in memory
        CALL    ASC16           ;convert it
;                       set ASCII sign
ASC32D: POP     SI              ;get sign
        MOV     AX,SI           ;put it in AL
        MOV     [BX],AL         ;and save it
        JMP     EXIT
ASC32   ENDP
```

LISTING 6: RN__F.ASM

```
RN_F    PROC    NEAR
;*****************************************************
;               Rounds a floating point operand to
;               the nearest integer value
;*****************************************************
        PUSH    SI              ;save index registers
        PUSH    DI
```



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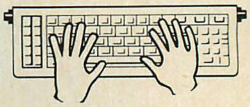

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```
        MOV     BX,CX           ;and BX
        MOV     DX,[DI]+2       ;get operand in DX:AX
        MOV     AX,[DI]
;
        SUB     CX,CX           ;clear CX
        MOV     DI,10000000B    ;isolate sign in DI
        AND     DI,DX
        OR      DX,10000000B    ;restore leading one
;                       check range
        CMP     DH,128          ;exponent bias is 128
        JA      RN1
        JB      RN7             ;if exponent<0 round to zero
;                       exponent is zero
        CMP     DL,128          ;number >= .5 and < 1
        JBE     RN7             ;if fraction=0 round to zero
        MOV     DX,CX           ;round to +1-all zeros
        MOV     AX,CX
        MOV     BH,81H          ;and biased exponent of 1
        JMP     RN6             ;restore sign and exit
;
RN1:    MOV     BH,DH           ;exponent in BH in case we exit
        CMP     DH,152          ;if exponent>=24, already integer
        JAE     RN6             ;so restore sign and exit
;                       exponent is in range 1-23
        MOV     CL,DH           ;put unbiased exponent in CX
        SUB     CX,128
        NEG     CX              ;COUNT is CX - 24
        ADD     CX,24
;                       shift right COUNT bits
        SUB     DH,DH           ;clear DH
        MOV     BH,DH           ;and BH
RN2:    SHR     DL,1            ;shift it right
        RCR     AX,1
        RCR     DH,1            ;rotate fraction into DH:BX
        RCR     BX,1
        LOOP    RN2
;                       round
        OR      DH,DH           ;is guard bit on?
        JNS     RN4             ;if not, rounding not needed
        TEST    AX,1            ;if integer odd
        JNZ     RN3             ;round up
        CMP     DH,80H          ;if any trailing bits on
        JA      RN3             ;round up
        OR      BX,BX
        JZ      RN4
RN3:    ADD     AX,1            ;round up
        ADC     DX,0
;                       normalize--shift left
RN4:    MOV     BH,152          ;set exponent to zero
RN5:    SHL     AX,1            ;shift left
        RCL     DL,1
        DEC     BH              ;increment exponent
        OR      DL,DL
        JNS     RN5             ;shift again if not normalized
;
RN6:    JMP     FINISH          ;restore sign and exit
RN7:    SUB     DX,DX           ;zero result
        MOV     AX,DX
        MOV     BX,DX
        JMP     EXIT
RN_F    ENDP
```

LISTING 7: INT__F.ASM

```
INT_F   PROC    NEAR
;*****************************************************************
;                       rounds and converts a floating point number
;                       to a signed 32-bit integer
;*****************************************************************
        PUSH    SI              ;save index registers
        PUSH    DI
        CALL    RN_F            ;round to nearest integer
                                ;rounded result now in DX:AX
        SUB     CX,CX           ;clear CX
        MOV     DI,10000000B    ;isolate sign in DI
        AND     DI,DX
```

```
        OR      DL,10000000B    ;restore leading 1
;
        MOV     CL,DH           ;exponent in CX
        SUB     DH,DH           ;clear DH
        SUB     CX,128          ;remove exponent bias
;               exponent in range 0 < exponent <=31?
        JLE     INT7            ;return 0 result with underflow
        CMP     CX,32           ;must be less than 32
        JGE     INT8            ;return overflow
;                       shift left or right
        SUB     CX,24
        JE      INT4            ;if exponent = 24, no shift
        JL      INT2            ;if exponent < 24, shift right
INT1:   SHL     AX,1            ;shift left
        RCL     DX,1
        LOOP    INT1
        JMP     INT4
;                       shift right
INT2:   NEG     CX
INT3:   SHR     DX,1
        RCR     AX,1
        LOOP    INT3
;
INT4:   SUB     BX,BX           ;completion status=0  OK
;                       check sign
INT5:   OR      DI,DI
        JZ      INT6            ;if number was negative
        NOT     DX              ;negate it
        NOT     AX
        ADD     AX,1
        ADC     DX,0
;
INT6:   JMP     EXIT
INT7:   JMP     UNDER_F
INT8:   MOV     DX,7FFFH        ;return maximum signed integer
        MOV     AX,0FFFFH
        MOV     BX,1            ;completion status=+1
        JMP     INT5            ;check sign
INT_F   ENDP
```

LISTING 8: ASC__F.ASM

```
ASC_F   PROC    NEAR
;*****************************************************************
;                       converts a binary floating point operand
;                       to ASCII decimal. SI points to f.p. number
;                       DI points to end of ASCII location. Returns
;                       offset to first character (sign) in BX
;*****************************************************************
        PUSH    SI
        PUSH    DI
        SUB     DX,DX           ;clear DX & CX
        MOV     CX,DX
;                       check for zero
        MOV     AX,[SI]+2
        OR      AX,AX
        JNZ     ASCF0
        JMP     ASCF11
ASCF0:  PUSH    BP              ;we'll use BP to address stack
;                       get sign
        MOV     BL," "          ;assume sign positive
        OR      AL,AL
        JNS     ASCF1
        MOV     BL,"-"          ;sign is negative
ASCF1:  PUSH    BX              ;save sign
;               compute LOG10(X)=LOG2(X)xLOG10(2)
;                       =(E-1) x 0.3 (approximately)
;                       do this in fixed point
        MOV     AL,AH           ;exponent in AX
        MOV     AH,DH
        SUB     AX,129          ;unbiased E=E-1 (E-128-1)
        JGE     ASCF2           ;if negative
        NEG     AX              ;make it positive
        DEC     CX              ;and set flag in CX
ASCF2:  MOV     BX,4CCDH        ;.3 decimal = .4CCD hex
        MUL     BX              ;U=E * LOG10(2) =DX.AX
        JCXZ    ASCF3           ;if E was negative
        NEG     DX              ;make U negative
;               adjust for number of places
```

```
ASCF3:  SUB     DX,6                ;V=U+1-7
        MOV     CX,DX
        CMP     CX,-38              ;V < -38 will give overflow
        JGE     ASCF4
        MOV     CX,-38              ;so make it -38
;                       compute 10^V
ASCF4:  MOV     SI,OFFSET IM2       ;set pointers to parameter
        MOV     DI,OFFSET IM1       ;areas IM1 & IM2
ASCF5:  PUSH    CX                  ;keep V--it is decimal exponent
        MOV     IM1,0               ;floating point ten in IM1
        MOV     IM1+2,8420H
        MOV     IM2,CX              ;V in IM2
        CALL    IPOWER_F            ;raise 10 to the V
;                       compute W=ABS(X)/10^V
        MOV     IM2,AX              ;10^V in IM2
        MOV     IM2+2,DX
        MOV     BP,SP
        MOV     BX,[BP]+4           ;get address of X from stack
        MOV     AX,[BX]             ;get f.p. operand X
        MOV     DX,[BX]+2
        AND     DL,7FH              ;delete its sign--ABS(X)
        MOV     IM1,AX              ;and put it in IM1
        MOV     IM1+2,DX
        CALL    DIV_F               ;DX:AX=W=IM1/IM2=ABS(X)/10^V
        POP     CX                  ;V in CX
;                       adjust W--maximum 7 digits
        CMP     DX,9818H            ;if W >= 10^7
        JA      ASCF6
        JB      ASCF7
        CMP     AX,9680H
        JB      ASCF7
ASCF6:  ADD     CX,1                ;V=V+1
        JMP     ASCF5               ;do it again
ASCF7:  CMP     CX,-38              ;can V be decremented?
        JLE     ASCF9
        CMP     DX,9474H            ;if W <= 10^6-1
        JA      ASCF9
        JB      ASCF8
        CMP     AX,23F0H
        JA      ASCF9
```

```
ASCF8:  DEC     CX                  ;V=V-1
        JMP     ASCF5               ;do it again
;                       convert to ASCII
ASCF9:  MOV     BP,SP
        MOV     DI,[BP]+4           ;point to ASCII location
        MOV     IM1,AX              ;W in IM1
        MOV     IM1+2,DX
        MOV     IM2,CX              ;exponent in IM2
        CALL    ASC16               ;convert exponent to ASCII
        MOV     DI,BX               ;BX points to sign
        CMP BYTE PTR [DI]," "       ;if positive exponent
        JNE     ASCF10
        MOV BYTE PTR [DI],"+"       ;make sign explicit
ASCF10: DEC     DI                  ;point to next byte
        MOV BYTE PTR [DI],"E"       ;store the E
        DEC     DI                  ;and point to next postion
;                       convert mantissa--W
        PUSH    DI
        MOV     DI,OFFSET IM1       ;point to W
        CALL    INT_F               ;convert W to two-word integer
        MOV     [DI],AX             ;integer W in IM1
        MOV     [DI]+2,DX
        MOV     SI,DI               ;W is second operand
        POP     DI                  ;ASCII location is first
        CALL    ASC32               ;convert it
        POP     AX                  ;get the sign
        MOV     [BX],AL             ;and store it
        POP     BP
        JMP     EXIT
;                       here for zero input
ASCF11: MOV WORD PTR [DI],"0 "      ;this will be stored as " 0"
        MOV     BX,DI
        DEC     BX                  ;offset in BX
        JMP     EXIT
ASC_F   ENDP
```

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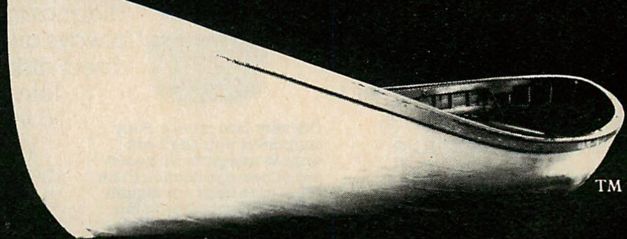

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Compatibles and Copyrights

A pop quiz on third-party, IBM-compatible BIOS

If when you saw the words *pop quiz* above you tried to move the top element of your stack to the "Quiz" register, cut it out. Nobody likes a smart-aleck machine language programmer.

What I mean by *pop quiz* is the following short questions that will test your knowledge of several legal issues discussed in this column in recent months. If you have no interest in being tested, you can just read the "Factual Background" and go straight to the answers.

FACTUAL BACKGROUND

The September issue of *PC Tech Journal* reported on the announcement of a third-party BIOS ROM, functionally identical to IBM's copyrighted BIOS, yet not infringing IBM's copyright. IBM's copyright on its proprietary BIOS has proved a major source of difficulty to the manufacturers of IBM compatibles, since IBM does not license its BIOS.

The company and its attorney declined to provide a copy of the license agreement, which apparently contains a confidentiality provision that covers the agreement itself. Without having seen the license agreement, it is impossible to analyze specifics, but the concept of a third party producing compatible software raises concrete questions that have been dealt with only abstractly in prior columns.

Let us suppose that a manufacturer of IBM-compatible computers (licensee) purchases a license from a third-party author of a truly IBM-compatible BIOS (licensor), incorporates the BIOS in a ROM chip and begins marketing.

THE QUIZ

Question #1: Can there be an IBM-compatible BIOS that does not infringe IBM's copyright?

A. Yes. It's a free country.
B. Yes. Copyright does not protect ideas per se.
C. No. The concepts of compatibility and originality are inherently inconsistent.

Question #2: Can the licensee use the licensed BIOS program to produce a BIOS ROM chip?

A. Yes. That's what a license is for.
B. Yes. Even if not explicitly set out in the written agreement, it would be fair use.
C. No. A license covers only exact duplication, including both the content and the medium.
D. It depends.

Question #3: If IBM sued the licensee for infringement, what outcome would you expect?

A. IBM would probably win because, by definition, the licensed BIOS would have to perform the same functions as the IBM copyrighted version.
B. The licensee would probably win, because a BIOS is applications, not operations, software.
C. IBM would probably win, because a BIOS is operations, not applications software.
D. The licensee would probably win, because it paid for the right to use the program.
E. The licensee would win if, but only if, the third-party BIOS did not violate IBM's copyright.

Question #4: If IBM sued the licensee and won, and the licensee in turn sued the licensor, which party would likely win?

A. The licensee, because it paid for the right to use the program and it has been prevented from doing so (implied warranty of merchantability).
B. The licensee, because a licensor indemnifies its licensees against infringement claims.
C. The licensor, because being sued by IBM is an act of God.
D. It depends.

MY ANSWERS

Question #1: my answer is B. Copyright protects artistic expression, not ideas ("The Basic Tools of U.S. Intellectual Property Law," November/December 1983, page 213). This was one of the arguments advanced by Franklin in its defense of Apple's copyright infringement case: Section 102(b) of the Copyright Act provides that "in no case does copyright protection . . . extend to any idea, procedure, process, system, method of operation, or dis-

Max Stul Oppenheimer, PC, is a partner in the law firm of Venable, Baetjer & Howard in Baltimore. The PC stands for Professional Corporation. He was convinced by his article in the October issue.

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covery, regardless of the form in which it is embodied."

Had Franklin independently developed its own program that emulated Apple's programs, there is little doubt that it would have prevailed. Franklin's argument took a slightly different tack: that there were so few ways to emulate the system that the idea and its expression were inseparable and therefore literal copying should be permitted. ("Memories Are Made of This," June 1984, p. 34). While it is possible to write a non-infringing, IBM-compatible BIOS, whether the licensor has done so is a factual question. Among the elements a court would consider is the degree of similarity and whether the compatible's programmers had access to the original program. Compatibility and originality could coexist, for example, if it could be shown that the programmers had access to the technical specifications of the BIOS (necessary to assure compatibility), but not the code itself.

Question #2: my answer is D. All of the other answers are examples of what one might reasonably expect to find in a license agreement, but legal contracts are governed by the terms the parties set. Assuming the third-party BIOS is copyrightable, the owner of the copyright has a bundle of rights under the Copyright Act, and he can divide them as he sees fit. He could, for example, license one party to use the program on IBM computers and another party on Compaqs, or one party on cartridges and another party on disks ("Disputing the Rights to Custom-designed Software," July 1984, p. 185).

The "fair use" answer presents an interesting issue. Normally, a "fair" use of a copyrighted work involves the use of a portion of the entire work for a non-commercial purpose ("Sony Versus Universal Studios: So What?" May 1984, p. 197). However, a licensee of the entire work for one commercial pur-

pose might argue that another commercial use was fair use. The best course is to obtain a license broad enough to cover all intended uses.

Question #3: my answer is E. If the third-party BIOS does not infringe IBM's copyright, its incorporation onto a ROM chip cannot give rise to infringement. ("Memories Are Made of This," June 1984, p. 34). Answer A is wrong for reasons discussed concerning question #1 above. The operations/applications distinction (if it exists), would work the reverse of the way that answers B and C suggest. If answer D were correct, there would not be much left of copyright law, would there?

Question #4: my answer is D. Again, the parties to a contract are essentially free to divide risks as they choose. As a licensee, one might expect to be indemnified against infringement claims challenging the licensor's rights. In the absence of an explicit provision, it might, under appropriate circumstances, be inferred that the licensor would indemnify the licensee. However, a license agreement could be drafted to place all risk of infringement on the licensee. (The licensee still might have some other basis for a complaint against the licensor if, in fact, the licensor had violated another party's copyright; answer A might be one approach, but "implied warranty of merchantability" means that the program will perform as it should, not that the licensee will be able to sell his product.) Columns in the July and August issues ("Disputing the Rights to Custom-designed Software," July 1984, p. 185 and "Go for Broker," August 1984, p. 181) discuss the latitude parties have in negotiating contract terms.

SCORING

If you answered any question correctly, thanks for reading at least some of the columns I worked so hard on.

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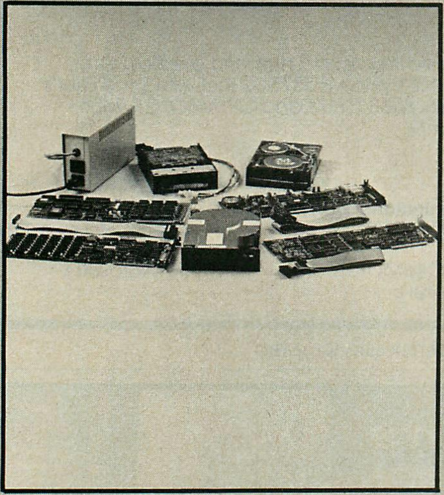

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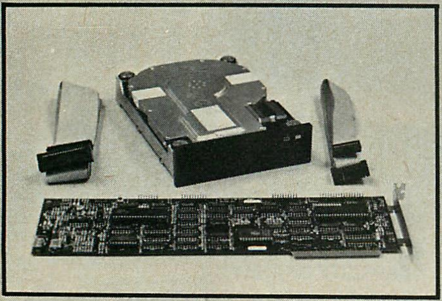

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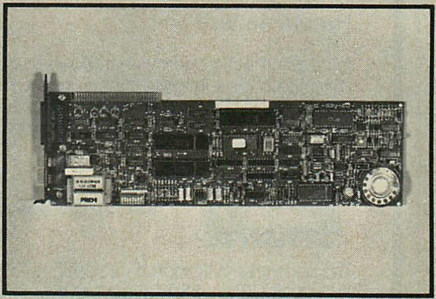

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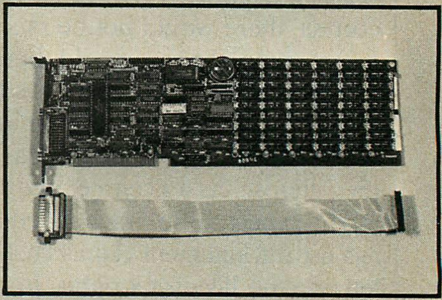

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The IBM Personal Computer from the Inside Out
Murray Sargent and Richard Shoemaker
(Addison-Wesley, Reading, MA, 1984)
445 pages, $16.95

Three weeks before I was asked to review this book, my department chairperson placed a copy of it on my desk and suggested that I consider using it instead of Leo Scanlon's *IBM PC Assembly Language* in a microprocessor course that I teach. I was quite interested in what Sargent and Shoemaker had to say in their new text, since I firmly believed that Scanlon's book was the best on the market as an introductory text for assembly language programmers. (See my review in *PC Tech Journal*, October 1984, p. 195.)

This book is not a replacement for Scanlon's book, but it is the next step in a growing cycle for those learning how to control the IBM PC "from the inside out." Let me suggest that in a reasonable reading sequence, this book would fall right after Scanlon's book and *Inside the IBM PC* by Peter Norton and before *The IBM PC Connection* by James Coffron. If I were to describe the text in a single sentence, I would say, "it is similar to Peter Norton's book but written in assembly language."

The 445 pages of the text are divided into 12 chapters of high-paced learning. If you are familiar with assembly language programming, then you can slide—not skip—through the first four chapters of the book. I would highly recommend, regardless of your background, a good look at the examples contained in these chapters. The authors take the time to show how to enter simple programs with DEBUG and more complicated programs with the IBM Macro Assembler. On page 46, the authors show a model of a typical assembly language program. This example will form the foundation of all your assembler programs. Do not miss the great examples, near the end of chapter 4, of interfacing assembly language programs to high-level languages. The examples include routines in Pascal, BASICA and FORTRAN. More detailed examples are lacking, but, of course, that is why the Scanlon book should be read first.

In order to prepare the reader for a discussion of IBM hardware, chapter 5 is an "Introduction to Digital Circuitry." While the treatment of material is good, it is very, very fast. Beginners working on their own may want to start with Heathkit's *Digital Logic Techniques* as a foundation.

If you have had experience with assembler software and digital hardware or have taken my advice and done the extra reading then you are well prepared for the treats of the remaining chapters in the book.

Sargent and Shoemaker start chapter 6 with the statement: "At first it seems like magic, but it's really just plain logic!" It is within this chapter that the authors dissect the system boards of the IBM PC and PC*jr*. An excellent treatment of the 8088 chip is given in terms of pinouts and timing. Concepts, such as the system bus, I/O, ROMs, and RAMs are treated well along with the specialized circuits using 8255, 80186, 8259A, 8253, and 8237 chips.

The next chapter covers data transfer methods between the CPU and I/O devices. While several data transfer methods are mentioned, the chapter centers on real-time interrupts. Several interesting assembly language programs illustrate various concepts. The chapter concludes with a discussion of real-time clocks and how data can be synchronized.

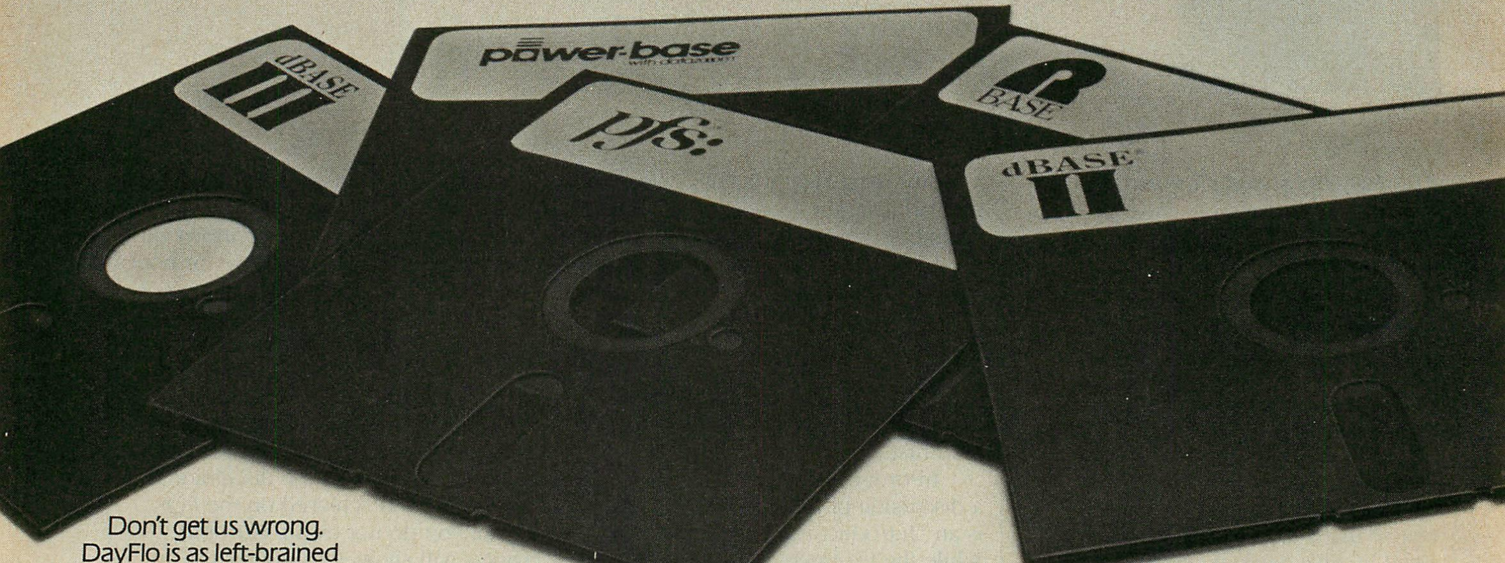
After a short discussion of the IBM PC keyboard and an even shorter discussion of the PC*jr* keyboard, the material in chapter 8 keys in on various video display techniques available for both machines. The authors do a fine job of explaining CRT tubes, color displays, and monochrome displays. They have also included a discussion of the Hercules Graphics Card (for the monochrome display) and one for the IBM color/graphics adapter. One of the fine points of this book is the discussion of how graphics is achieved on the PC*jr*. Even if you do not own a PC*jr*, this chapter will show you another way to get the job done.

Chapters 9 and 10 are chapters on applications involving hardware interfacing. Chapter 9 is one of my favorite chapters because it shows the user how to interface the computer to switches, relays, photoresistors, SCRs, digital-to-analog converters and stepper motors. Chapter 10 concentrates on the hardware of data communications. In this chapter, a complete discussion of parallel and serial conversion is provided. UARTs (Universal Asynchronous Receiver Transmitter) are presented in conjunction with the RS-232 port concept for serial transmission of data. A detailed description of data transmission techniques is presented in the sections dealing with modems, fiber optics, RF (*R*adio *F*requency), powerline, and IR (*I*nfra*R*ed) carriers.

The book ends with a chapter on building your own interfaces for the IBM PC. The authors present a very good construction example for building a wire-wrapped serial/parallel interface board. I am just sorry this was their only example for the chapter. If you are a beginner at building logic circuits, this is simply not the place to start. One wiring mistake could end your project in a cloud of smoke.

—WILLIAM H. MURRAY

Traditionally, databases have been left-brained.



Don't get us wrong. DayFlo is as left-brained as any database around. It can handle structured information such as customer lists and personnel records. Keywords and field names are used to gain access to records.

Just like traditional databases.

However, solving traditional problems in traditional ways is just one side of DayFlo. It's also flexible enough to handle today's new challenges in exciting new ways.

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Which wreaks havoc on traditional databases. For example, because of fixed formats, entering a new field such as a Telex number into a single customer record is next to impossible. Unless you're prepared to reprogram and reformat your entire database.

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• Fixed field length.	• Variable field length. No counting character spaces.
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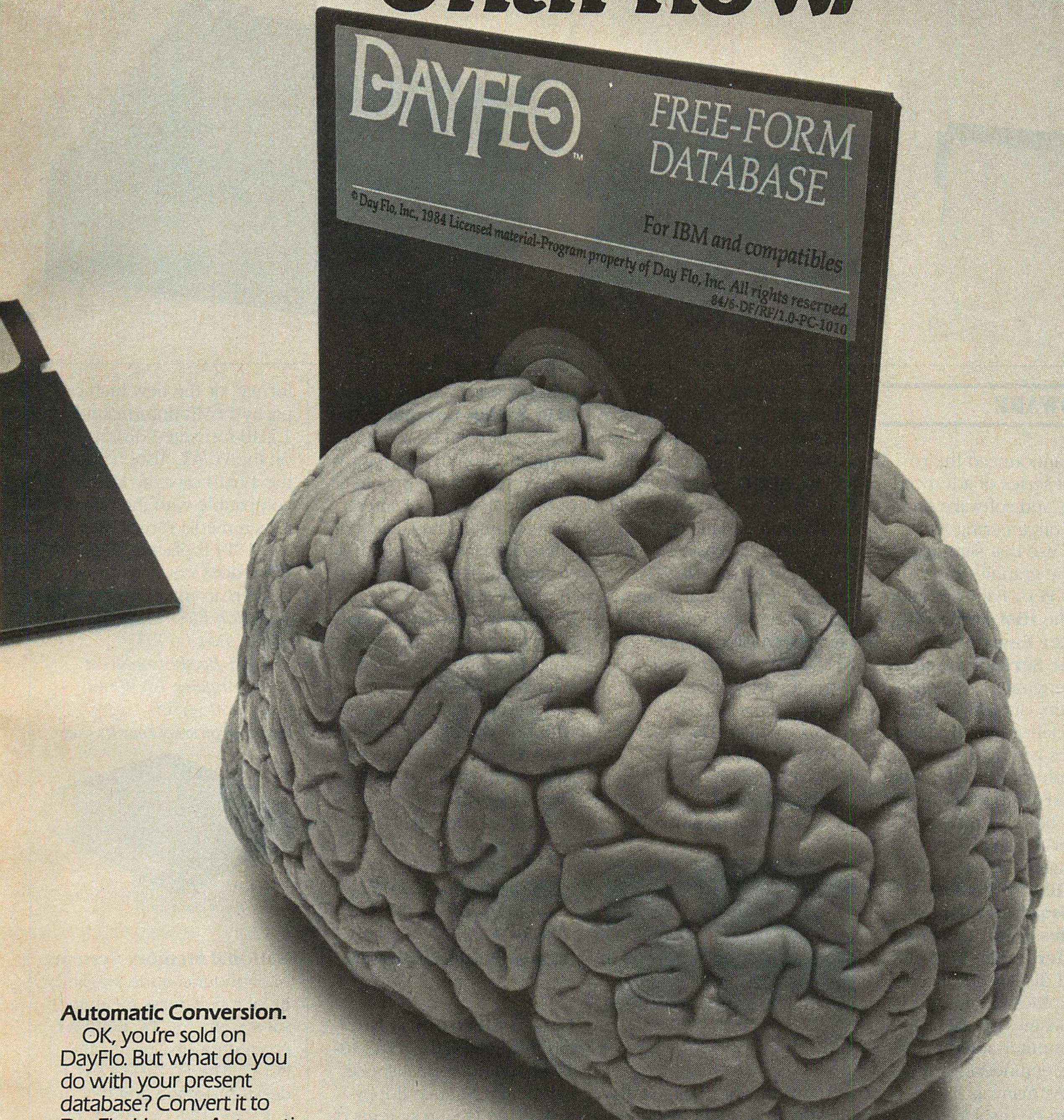

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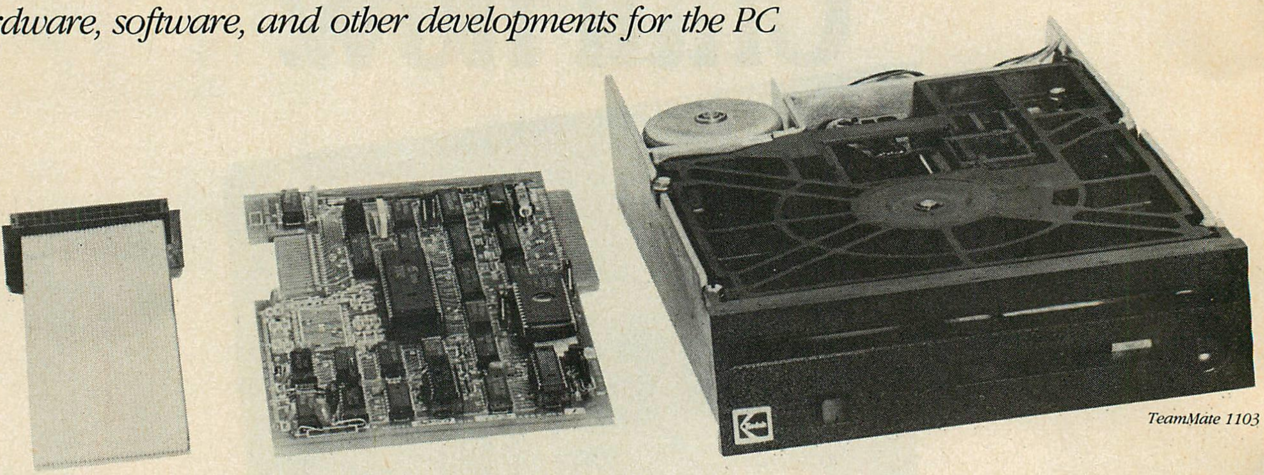

TeamMate 1103

HARDWARE

IBM has announced the release of a series of advanced hardware and software options for engineering and scientific use that significantly extend the graphics capabilities of its Personal Computer family. The **IBM Personal Computer Engineering/Scientific Series** is designed to assist engineers, scientists, researchers, and developers with specialized applications. The series is built around the new Graphical Kernel System (GKS) and can be used with a PC that has an Expansion Unit, or with a PC/XT or PC/AT. Prominent in the series are the **IBM PC Professional Graphics Display** and **Professional Graphics Controller**, which help generate and display advanced color graphics for product design, business presentations, computer-aided manufacturing, engineering, and science. As many as 256 colors can be displayed simultaneously from a palette of 4,096 colors.

IBM also introduced the **IBM PC Enhanced Color Display** and **Enhanced Graphics Adapter**, which are supported by GKS as well. These units offer high-definition text and graphics in as many as 16 colors simultaneously from a palette of 64 colors. The new display can be used with the PC, PC/XT, or PC/AT. In addition, the adapter can support high-quality graphics for the IBM PC Monochrome Display and expanded graphics capability for the IBM PC Color Display. Both Enhanced products will be available in January 1985. Prices: IBM PC Professional Graphics Display, $1,295; IBM PC Professional Graphics Controller, $2,995; IBM PC Enhanced Color Display, $849; IBM PC Enhanced Graphics Adapter, $524.

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CIRCLE 491 ON READER SERVICE CARD

IBM Personal Computer Engineering/Scientific Series

A 3.3MB flexible 5¼-inch disk subsystem that can be added to a personal computer as a low-cost alternative to Winchester disks or as an inexpensive, effective means of Winchester disk back-up is now available from the TeamMate division of **Data Technology Corporation**. The new **TeamMate 1103** subsystem family is based on a high-capacity, flexible-disk drive manufactured by **Eastman Kodak Company**; the drive features a servo and vertical clamping mechanism that eliminates the problems of thermal wear and interchangeability. The subsystem offers the largest single-disk storage capacity of any commercially available 5¼-inch flexible drive system; specifically, the diskette stores eight times the information of a standard IBM 360KB floppy and allows the user to work with one diskette instead of eight. Prices: TeamMate 1103 subsystem, $895; 3.3MB floppies, $15 each.

Data Technology Corporation
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408/496-0434

CIRCLE 490 ON READER SERVICE CARD

C. Itoh Electronics, Inc. has introduced the **YD-380-1714**, a unique dual-speed, half-height 5¼-inch floppy-disk drive. Giving systems designers the benefit of two standard formats in a single package, the YD-380-1714's dual-speed feature allows it to work with either the current standard format for 5¼-inch media, or the newly emerging high-capacity 5¼-inch media. The drive can read and write data at 96-tpi track density on either the current standard 1MB double-density, double-track format, or the new high-capacity 1.6MB-unformatted/1.2MB-formatted disk used on the PC/AT. Also, because the 1.6MB capacity is format-compatible with the standard 8-inch media format, the YD-380-1714 replacing an 8-inch drive does not require data to be rearranged. $300.

C. Itoh Electronics, Inc.
P.O. Box 66903
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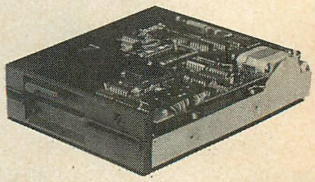
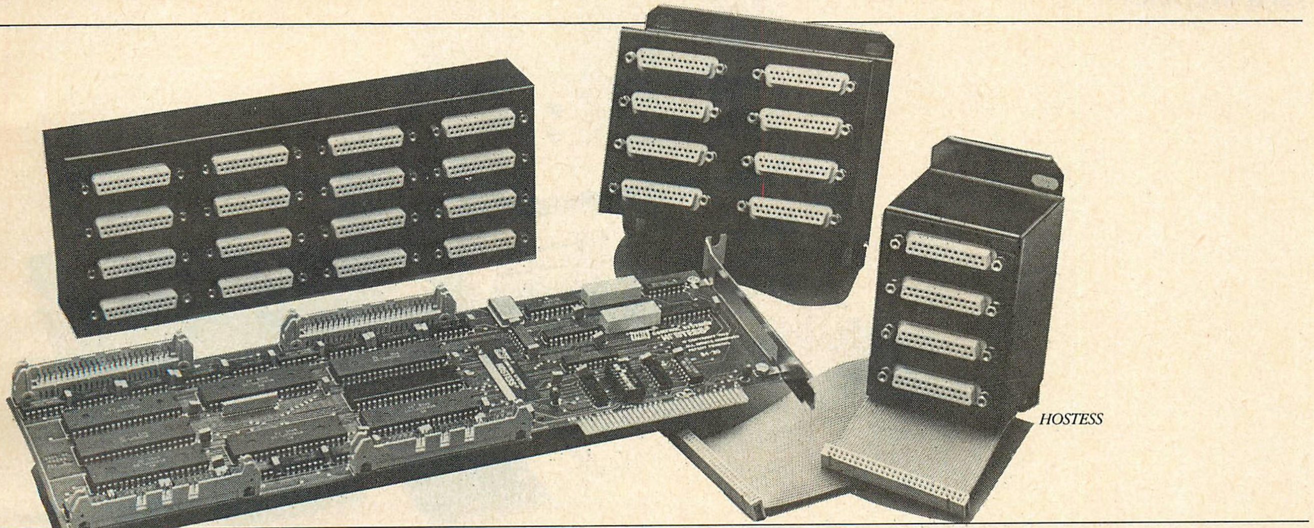


YD-380 floppy-disk drive

National Memory Systems has announced the availability of a new mass memory subsystem, the **PC 8000-AT**, created exclusively for the PC/AT. The PC 8000-AT is a desktop storage unit that provides 85, 170, or 335MB of add-on storage for the AT. For more storage capacity, rack-mountable units are available that provide up to 1,000MB capacity. The unit has disk data rates of 2.4MB per second and an average access time of 15 milliseconds. NMS also announced optional tape back-up systems for the PC and PC/AT. The **NMS PC.25** is a 67MB-per-cartridge, quarter-inch tape system and the **NMS-**



HOSTESS

9000-AT is a low-profile, 9-track 1600 BPI, ANSI-IBM format-compatible tape system. Prices: PC 8000-AT with 85MB, $5,900; with 170MB, $8,900; with 335MB, $13,100. NMS PC.25, $2,300 (special offer available through December 31, 1984); NMS 9000-AT, $5,700.

National Memory Systems Corporation
355 Earhart Way
Livermore, CA 94550
415/443-1669

CIRCLE 488 ON READER SERVICE CARD

The **HOSTESS** multi-user host adaptor board by **Control Systems** adds up to 16 additional serial ports to the PC or PC/AT; **HOSTBIOS** software allows users of PC-DOS to refer to these as ports 3 through 18. These ports are necessary to support the 16-user XENIX software and other serial devices on the PC/AT. Control Systems has been manufacturing the HOSTESS board for two years, but the company anticipates increased interest in the adaptor board with the introduction of the AT. The board comes in 4- and 8-port versions; two boards are required to support 16 ports. Addresses and interrupts are switch-selectible and do not interfere with COM1 or COM 2. Rear panel brackets are available for 4, 8, or 16 ports. HOSTESS is supported by several multi-user operating systems on the PC, including XENIX 68000, QNX, RMX-86, MULTILINK, and COHERENT, but HOSTESS can be used with PC-DOS for specialized communications applications. Prices: HOSTESS 4, $495; HOSTESS 8, $750; HOSTESS 16, $1,495; 4-Port Upgrade Kit, $295; HOSTBIOS, $75.

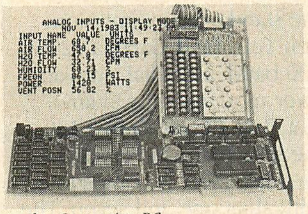
Control Systems
2855 Anthony Lane
Minneapolis, MN 55418
612/781-5043

CIRCLE 483 ON READER SERVICE CARD

Analog Connection PC, a new type of data acquisition system for the PC and PC/XT from **Strawberry Tree Computers**, is set up in menus, rather than by writing programs. It features direct connection to most types of sensors without adding interface modules. The system logs data, including maximum, minimum, average, and difference, on a printer or disk. It sounds alarms and controls equipment at levels entered in menus, and has 8 or 16 digital I/O lines and two analog outputs. Analog input resolution is 14 bits on 8 or 16 channels. Logged data are compatible with Lotus 1-2-3; modifications can be written in BASIC. Prices: 8 analog inputs with card only, $690, with terminal box, $889; 16 analog inputs with card only, $900, with two terminal boxes, $1,298.

Strawberry Tree Computers
949 Cascade Drive
Sunnyvale, CA 94087
408/736-3083

CIRCLE 486 ON READER SERVICE CARD



Analog Connection PC

Paradise Systems has announced its **Modular Graphics Card** for the IBM PC and PC/XT. The Modular Graphics Card supports any standard, unmodified color/graphics software on a monochrome, RGB, or composite monitor. It produces up to 16 colors on a color monitor or translates those colors into shades of green, gray, or amber on an IBM or equivalent monochrome monitor. The card's functions may be expanded by adding modules that provide additional enhancements: up to 384KB RAM; a clock calendar; a parallel, serial, or game port; and a floppy-disk controller. The modules fit into a single PC or PC/XT expansion slot without imposing on adjacent slots. Prices: Modular Graphics Card, $395; Module A (parallel, serial, or game port), $125; Module B (256KB RAM with clock, 384KB RAM, or a disk controller with a parallel port), $275.

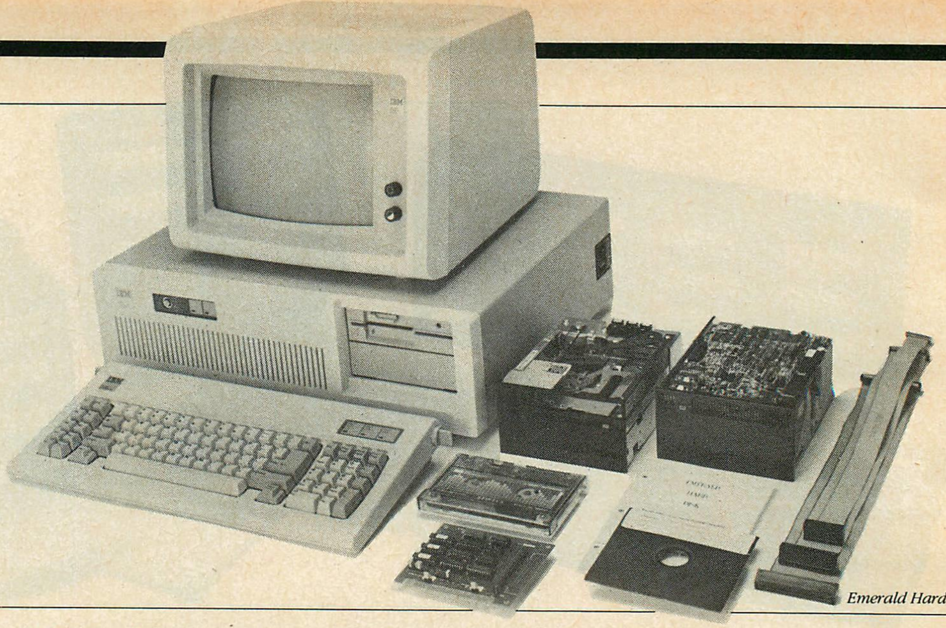
Paradise Systems, Inc.
150 North Hill Drive
Brisbane, CA 94005
415/468-6000

CIRCLE 487 ON READER SERVICE CARD

Nestar Systems, Inc. has announced that its complete family of networking products and applications software will not only support the PC/AT and PC Network, but will also enhance the IBM PC Network System capabilities. Nestar Systems will immediately support the PC/AT as a high-performance workstation on the PLAN Series network and will support the IBM PC Network Program when it becomes available in 1985. Nestar's products will be compatible with the IBM Program using the Nestar baseband, token-passing LAN products. The company has also announced an agreement with the U.S. General Services Administration (GSA) Office of Information Services Management. Under terms of the agreement, Nestar Systems' family of personal computer networking systems and related services are approved for purchase by all U.S. government agencies.

Nestar Systems
2585 East Bayshore
Palo Alto, CA 94303
415/493-2223

CIRCLE 477 ON READER SERVICE CARD

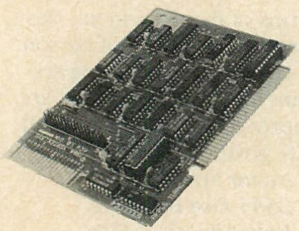


Emerald Hard Disk

Vertex Systems has released the **Apple-Turnover**, a board for the PC that allows direct transfer of files between Apple disks and IBM disks. The APPLEDOS 3.3 or APPLE CP/M disk is inserted directly into the IBM's disk drive. Individual APPLE or IBM disk files or entire disks can be copied. In addition, blank disks can be initialized (formatted) within the IBM for the APPLE; serial-file transfers and modems are eliminated. The Apple-Turnover software is fully menu-driven. The package contains a half-size, printed-circuit board, disk-drive attachment cable, file-transfer software, and an Apple test disk. The Apple-Turnover board is installed in any expansion slot, between the regular disk controller card and the normal IBM disk drives. It will run on the PC, PC/XT, and compatibles. $279.50.

Vertex Systems
7950 West 4th Street
Los Angeles, CA 90048
213/938-0857

CIRCLE 485 ON READER SERVICE CARD



Apple-Turnover

Ven-Tel, Inc. has announced that its line of internal modems for IBM computers has been successfully tested for compatibility with the PC/AT. The AT has eight internal expansion slots, three of which are used in the standard configuration. Ven-Tel's **Half Card**, a 1200/300 baud, auto-dial, auto-answer modem, runs in any slot. The **PC Modem 1200**, the standard-size version of the Half Card, is compatible with slots one and seven. The Ven-Tel modems are packaged with Crosstalk-XVI by Microstuf, a communications software package that features automatic dialing and log-on, terminal emulation, and automatic data capture. Crosstalk-XVI is also fully compatible with the PC/AT. Prices: PC Modem Half Card, $549; PC Modem 1200, $499.

Ven-Tel, Inc.
2342 Walsh Avenue
Santa Clara, CA 95051
408/727-5721

CIRCLE 480 ON READER SERVICE CARD

Mountain Computer, Inc. has announced two half-height, internal tape back-up models for the PC/AT. The **AT-FileSafe Tape** provides the same features, including error-correction logic, as Mountain's tape series for the PC and PC/XT, and is 100-percent compatible with PC-DOS 3.0. It is also compatible with the leading networks that will be supported on the AT, including the 3COM EtherSeries, Novell, Orchid PCnet, and NESTAR. The menu-driven interface provides users with considerable back-up flexibility. A complete 20MB AT fixed disk can be backed up in streamer mode in less than 10 minutes, yet can be restored file-by-file, or in groups of files, like a database. Users can create their own batch (command) files for virtually any combination of both back-up and restore options. AT-FileSafe software allows users to back up from one disk and restore to a different disk. Prices: AT-FileSafe Tape with 27MB, $1,595; with 60MB, $1,695.

Mountain Computer, Inc.
300 El Pueblo Road
Scotts Valley, CA 95066
408/438-6650

CIRCLE 481 ON READER SERVICE CARD

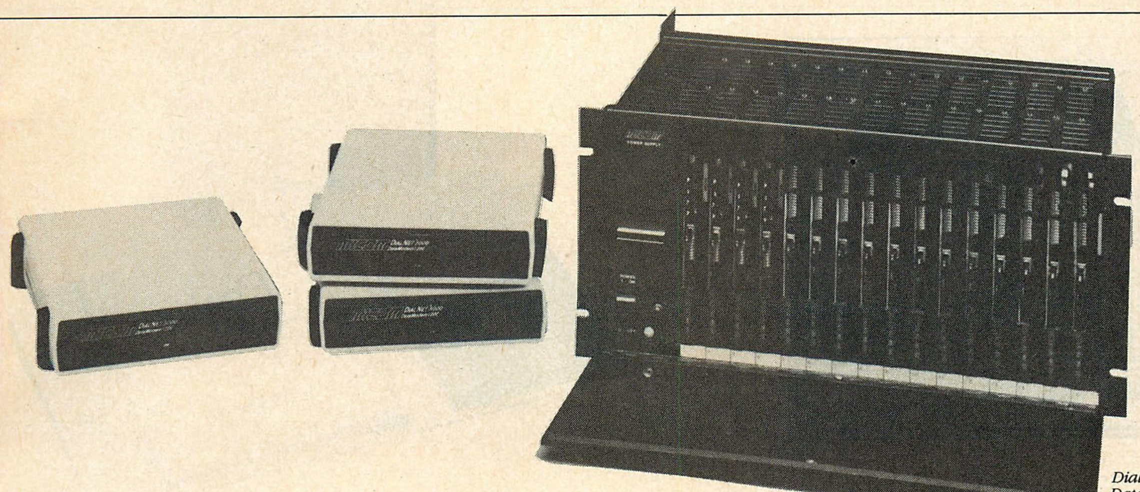
AT-FileSafe Tape

Emerald Systems Corporation has announced the release of a fixed-disk and ¼-inch tape drive internal upgrade kit for the PC/AT. The **Back Up & Restore Utility** (BRU) provides a comprehensive solution for the transfer of files to a removable medium. One 60MB tape acts as a personal librarian for retired files. Users may also archive their existing floppies to tape, as well as insure against data loss on the fixed disk. BRU provides both menu- and command-driven file management. Emerald's expansion systems are available in varying disk capacities. The internal upgrade kit uses IBM's fixed-disk controller, allowing full compatibility of AT software, and is installed within the AT's casing. A full upgrade kit includes fixed disk, ¼-inch tape drive, all necessary cables, BRU, menu-driven, fixed-disk installation software, and user manual. Prices: Basic internal PC/AT 60MB cartridge back-up kit, $1,950; Internal Fixed-disk Kits—40MB, $4,350; 65MB, $5,850; 140MB, $8,850; 280MB, $15,850.

Emerald Systems Corporation
4901 Morena Boulevard
San Diego, CA 92117
619/270-1994

CIRCLE 482 ON READER SERVICE CARD

The **DialNet 3000** family of 1200-bps modems for full-duplex communications over the dial telephone network has been introduced by MICOM. Capable of supporting asynchronous or synchronous devices, the new mo-



DialNet 3000
Data Modem family

dems include two dual-speed auto-answer units, plus another dual-speed modem with directory-driven autodialer. The four basic modems are each offered as desktop units or card modules. They can be controlled by the computer or terminal that they support and each has a nonvolatile memory for up to 20 telephone numbers. Stored numbers may be linked and may incorporate both pulse and tone dialing in the same number sequence. All DialNet 3000 modems can automatically answer incoming calls, adjusting their speed and transmission mode to match the calling modem. Prices: Model 3012, $495; Model 3012TA, $695; Model 3012+, $595; Model 3024, $795.

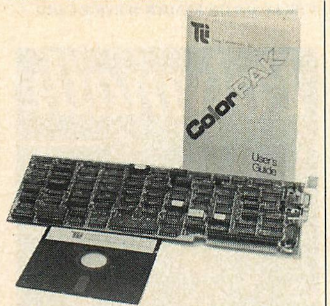
MICOM Systems, Inc.
20151 Nordhoff Street
Chatsworth, CA 91311
213/998-8844

CIRCLE 479 ON READER SERVICE CARD

ColorPAK, an ultrahigh-resolution color graphics board for the PC, PC/XT, PC/AT, and compatibles, has been introduced by **Tseng Laboratories, Inc.** With a high-resolution monitor, ColorPAK provides up to 640x400 resolution graphics display (noninterlaced, four-color) and 80x 50 screen display, thus addressing the requirement of end users who need clear text processing with their color graphics. ColorPAK can be configured to support both the standard IBM Color Monitor or high-resolution color monitor. Grafix Partner, a software package from Brightbill-Roberts that enhances the graphics generated by the user's own software, is included in the ColorPAK package. In addition, a **SoftPAK** option card, which provides for virtually 100-percent IBM software compatibility when using a high-resolution monitor, is available. Prices: ColorPAK, $580; SoftPAK, $99.

Tseng Laboratories, Inc.
205 Pheasant Run
Newtown Commons
Newtown, PA 18940
215/968-0502

CIRCLE 484 ON READER SERVICE CARD



ColorPak

Cytrol, Inc. has introduced **CyLock PC Access and Data Protection**, the first product in the CyLock PC Security System family. CyLock, a data security system for the PC and PC/XT, prevents unauthorized access to protected PCs, allows authorized users to encrypt and control data files for private or shared use, lets program owners protect software from unauthorized use and copying, and produces a security audit trail. The system consists of the CyLock PC expansion board, an external key receptacle, a Datakey memory device, CyLock software, and user documentation. After gaining authorized access to a protected PC with the use of a Data Key and corresponding password, individuals can use CyLock to safeguard their data and programs in a number of ways. Access authorization for each PC protected by CyLock is controlled by one PC Manager. CyLock allows eight users or groups of users to access a protected PC. $449.

Cytrol, Inc.
4620 West 77th Street
Edina, MN 55435
612/835-4884

CIRCLE 478 ON READER SERVICE CARD

SOFTWARE

Unicorn Systems Company has announced a menu-driven development tool that supports IBM's Customer Information Control System (CICS) applications development on the PC/XT 370. **MicroCICS** allows programmers to enter, compile, test, and debug CICS programs without having to access the mainframe until their completed code is ready to upload. MicroCICS also can be used for support of training activities and prototyping new applications to users. Initial license fee: $4,495, including user manual and 90-day warranty. Discounts available.

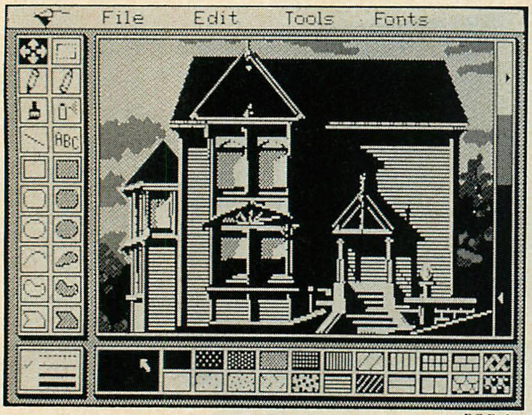
Unicorn Systems Company
3807 Wilshire Blvd.
Los Angeles, CA 90010
213/380-6974

CIRCLE 476 ON READER SERVICE CARD

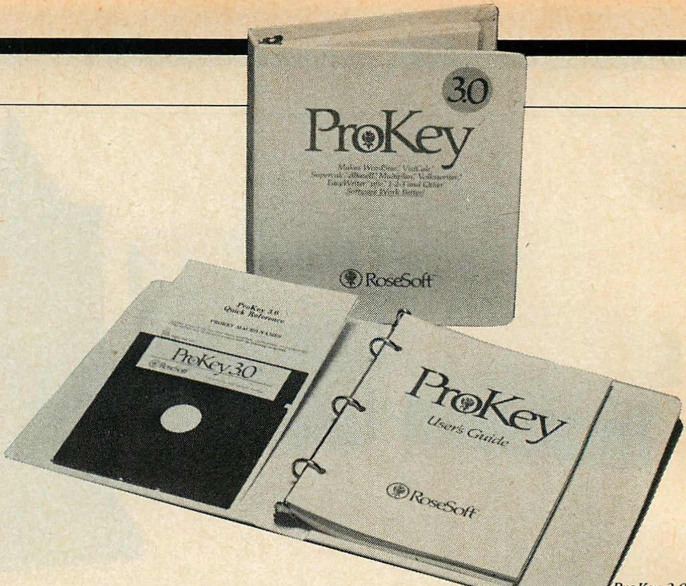
In conjunction with the introduction of The Connector, **Unisource Software Corporation** has announced a new version of VENIX/86, called **VENIX/Encore**. The new product's expanded features include the capability to write C programs larger than 64KB, the ability to write device drivers and integrate them into the system's kernal, the ability to run FORTRAN 77, and record-locking. VENIX/86 and VENIX/Encore were developed by VenturCom, Inc. of Cambridge, MA, and are distributed by Unisource. VENIX/Encore is delivered with a UNIX System V license. $800.

Unisource Software Corp.
71 Bent Street
Cambridge, MA 02141
617/491-1264

CIRCLE 472 ON READER SERVICE CARD



PC Paint



ProKey 3.0

The Connector, a new software product developed by **Uniform Software Systems Inc.**, enables both PC-DOS and UNIX applications programs to run on the same machine at the same time. With a single command, The Connector runs PC-DOS and its applications as UNIX tasks under PC/IX or VENIX. The Connector, which is contained on a single diskette, is being marketed by **Unisource Software Corporation**. $295.

Uniform Software Systems
1110 Eugenia Place
Carpinteria, CA 93013
805/684-5434

CIRCLE 474 ON READER SERVICE CARD

Unisource Software Corp.
71 Bent Street
Cambridge, MA 02141
617/491-1264

CIRCLE 473 ON READER SERVICE CARD

After conducting a series of tests using **ProKey 3.0** on the PC/AT, **RoseSoft Inc.** has announced that ProKey is compatible with IBM's new computer. According to company officials, the product often is considered a benchmark for testing claims of compatibility. ProKey is used to create "shortcuts" when using other software by enabling the user to press customized function keys to replay an entire sequence of keystrokes. More than 300 function keys can be created, each of which can save more than 10,000 characters and commands. ProKey also lets the user control the speed of execution of a definition, so that the PC could be left running to perform a task after the user leaves. $129.95.

RoseSoft Inc.
4710 University Way NE
Suite 601
Seattle, WA 98105
206/524-2350

CIRCLE 471 ON READER SERVICE CARD

A mouse-based color graphics package for the PC, XT, AT, PCjr, and compatibles has been introduced by **Mouse Systems**. Called **PC Paint**, the program features a color bar, line-width box, patterns, shapes, and drawing tools such as Pencil, Paintbrush, Spraycan, and Text. Commands include Magnify, Show Screen, Change Colors, Undo, Cut and Paste, and Invert Colors. Type font and size can be set and pictures can be printed on either a dot matrix or inkjet printer. PC Paint is supported by PC Mouse or any Microsoft-compatible mouse. $99.

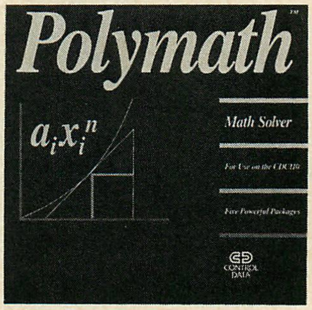
Mouse Systems
2336H Walsh Avenue
Santa Clara, CA 95051
408/988-0211

CIRCLE 475 ON READER SERVICE CARD

Control Data Corporation has developed a new applied mathematics program, called **POLYMATH**, that allows PC users to solve complex mathematical and algebraic equations on their computers. POLYMATH consists of four mathematical packages: polynomial curve fits, linear/nonlinear equation solver, ordinary differential equation simulator, and general multiple regression. POLYMATH requires no computer programming experience. Users enter equations and values and the program chooses the solution method. All messages are given in English and math symbols. $150.

Control Data Corp.
8100 34th Avenue South
Box 0
Minneapolis, MN 55440
612/853-4636

CIRCLE 469 ON READER SERVICE CARD



Polymath

Optisolve, a second generation microcomputer equation-solving program, has been released by **Optisoft**. It is intended for use by scientists, engineers, students, financial planners, or anyone who deals with mathematical formulas and equations. Mathematical problems are entered as they would appear in a textbook; no programming knowledge is necessary. When a system of equations has more than one solution, Optisolve gives all of them. When there are an infinite number of solutions, it gives the optimal one with respect to user-defined criteria. Optisolve can be linked with C programs using Lattice C or Microsoft C and soon will be capable of linking to FORTRAN programs. $195.

Optisoft
1445 Crone Avenue
Anaheim, CA 92802

CIRCLE 468 ON READER SERVICE CARD

Three new C language libraries have recently come on the market from **Greenleaf Software, Software Horizons**, and **Vance Info Systems**. Greenleaf has released a major update to its **Greenleaf Functions**, which provides more than 200 routines, including nearly all DOS and BIOS capabilities, string handling, and color text. The library supports Computer Innovations' C86 version 2.0, Lattice C, Microsoft C, and the DeSmet C-Ware compiler.

Software Horizons has introduced **C-POWER PACKS**, a

LinkWare: Information Server

complete line of six libraries featuring preprogrammed functions and subassemblies. The libraries contain more than 600 functions and can be mixed and matched. They interface with DOS 2.0 and earlier DOS versions and support Lattice C and Microsoft C. Prices start at $99 and vary on number and types of functions.

From Vance Info Systems comes **C lib**, a C function library containing more than 200 routines. It is available now under the DeSmet C-Ware compiler and soon will be available in Microsoft C, Lattice C, and other C compilers. Among its features are a windowing library transportable with XENIX function calls, compatible UNIX functions, and capability to convert floating-point numbers from Microsoft to 8087 NDP format. $145.

Greenleaf Software
2101 Hickory Drive
Carrollton, TX 75006
214/446-8641

CIRCLE 467 ON READER SERVICE CARD

Software Horizons
165 Bedford Street
Burlington, MA 01803
617/273-4711

CIRCLE 466 ON READER SERVICE CARD

Vance Info Systems
2818 Clay Street
San Francisco, CA 94115
415/922-6539

CIRCLE 465 ON READER SERVICE CARD

A new software product that controls the transfer of information among different types of computer systems has been introduced by **Linkware Corporation**. Called **Linkware: Information Server** (L:IS), the product provides a network application called a *virtual server*, which resides on host computers and acts as a staging area for information. It lets users access and transfer information and provides control by matching files to user IDs for proper security clearance. Available with L:IS is a PC Connection that allows upload and download of text and data files between the PC and L:IS. PC Connection operates on IBM PCs and compatibles. Prices: $200 to $350 per copy depending on quantity ordered; PC Connection option, $15,000.

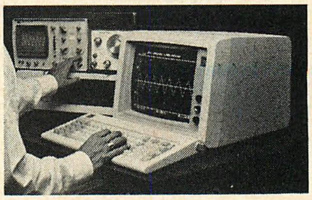
Linkware
77 Rumford Avenue
Waltham, MA 02154
617/894-9330

CIRCLE 470 ON READER SERVICE CARD

Signal Technology Inc. (STI) has announced that a compatible subset of its Interactive Laboratory System (ILS) signal processing software has been ported to the IBM PC and PC/XT. Called **ILS-PC 1**, the new software offers the first PC version of the ILS package, which includes more than 30 integrated programs providing data acquisition support, waveform display and editing, digital filtering, and spectral analysis. Applications include speech analysis, seismology, acoustics, sonar, and radar. ILS-PC 1 requires 256KB of memory and a graphics board running DOS 2.1 An 8087 is recommended. The license fee is $1,495.

Signal Technology Inc.
5951 Encina Road
Goleta, CA 93117
800/235-5787
805-683-3771 (in California)

CIRCLE 463 ON READER SERVICE CARD



ILS-PC 1

Smith & Smith Associates has released a C language cross-reference called **CrossRefC**. The product creates a listing file from source code with page and line numbers and an appendix of all user-defined mnemonics, their data type, the line numbers on which they are referenced, and the type of reference. CrossRefC also creates a symbol table file that lists in alphabetical order by mnemonic the mnemonics' data type, where they are defined, and the modules that reference them. Pitch, paper width, and other default print attributes may be redefined via command line arguments. Standard C I/O file redirection is supported. $39.95.

Smith & Smith Associates
P.O. Box 160
Hunt Valley, MD 21030
301/357-4387

CIRCLE 461 ON READER SERVICE CARD

A new release of **C EXECUTIVE**, a real-time monitor that now supports the full 1MB of physical address space of the 8086/88/186, has been announced by **JMI Software Consultants**. Release 1.5 is packaged in both binary and source form. It allows multiple C and/or Pascal tasks to run concurrently with intertask communication, resource coordination, and formatted I/O. Multiple-user terminals can be supported with UNIX-like characteristics. The package comes with the Portable C Library, containing more than 100 routines. $500 (plus $75 for documentation and media).

JMI Software Consultants
904 Sheble Lane
P.O. Box 481
Spring House, PA 19477
215/628-0846

CIRCLE 460 ON READER SERVICE CARD

TECH BOOK *A Special Section for Product and Service Listings*

ACCESSORIES/SUPPLIES

IBM STYLE BINDERS, SLIPS
Complete program packaging line. D-ring cloth binders, slip cases, floppy pages, game portfolios. Continuous paper with three large holes, 20 lb. to go in binders. Blank disk envelopes. Function key cards tell user your F1-F10 meanings. Call, write for prices. Catalog. Fast service, low prices
ANTHROPOMORPHIC SYSTEMS LIMITED
376 E. St. Charles Road
Lomobard, IL 60148
(312) 629-5160

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PO Box 561952, Dept PCT
Miami, FL 33256-1952
(305) 665-6617

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FIXED DISK BIOS/BOOT
fiXT boots from DATAMAC, DAVONG, XEBEC, PERCOM, GREAT LAKES, ZOBEX, others. Adds XT-like BIOS interface for your disk to IBM PC or COMPAQ. Plug-in installation. DOS 2.0/3.2/reqd. Specify controller model with order \$70 + \$3 shpg. + tax. MC/VISA (optional volume support at additional cost.)
GOLDEN BOW SYSTEMS
P.O. Box 3039
San Diego, CA 92103
(619) 298-9349

DT2801 SERIES ANALOG I/O
Plug-in data acquisition boards with 8DI/16SE analog inputs, high or low level programmable gains, 2 analog outputs, 16 lines of digital I/O, DMA, on-board clock, and on-board microprocessor. Optional software subroutines and screw terminal panels.
DATA TRANSLATION INC.
100 Locke Drive
Marlboro, MA 01752
(617) 481-3700

TOTAL PC&XT INPUT/OUTPUT
ESE introduces two extremely powerful communications adapters for the PC&XT & compatibles. One is a unique multi-interrupt RS-232 serial add-on for one OR MORE users; \$139.50, and the second is a programmable 24 line parallel interface; \$119.45. Both have ESE's full 64K selectable I/O address decoders.
ELECTRONIC SYSTEMS ENGINEERING
477 Congress Street, Suite 911
Portland, Maine 04104
MC/VISA (207) 773-7778

HARDWARE COMMUNICATIONS

"VOICE I/O FOR THE IBM PC" Talk back to your PC! Add voice I/O to your application with a DIALOG sound digitizer board. Features include phone interface, tone decoding, modem. High fidelity, low data rate. We provide device drivers, demos, code examples, HLL link ('C", Pascal, and BASIC), manual, OEM support. Call for more details.

DIALOGIC CORPORATION
164 McKinley Avenue
East Hanover, NJ 07936
(201) 386-0202

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1.2MB PC-AT DISK DRIVES
Replace your PC disk controller and full-height disk drive with our JDISKETTE controller plus our 1.2MB and 360k half-height drives for \$499. Only \$375 without 360K drive, \$549 with two 1.2 MB drives. Put 800K on ordinary diskettes. 1.2MB diskettes are \$59 per box (10). Mounting brackets, and JFORMAT included. Jdiskette also plugs into our JRAM-2 multifunction board.

TALL TREE SYSTEMS
1032 Elwell Court, Suite 124
Palo Alto, CA 94303
(415) 964-1980

HARDWARE/MONITORS

PC DISPLAY TESTER
The pocket sized Montest-PC provides on-site testing of mono-chrome and color PC monitors. It permits individual testing of all three colors and video intensification. Attached to the display by a 9-pin D. The presence of a vertical bar, with an intensifiable right half, indicates a working monitor. \$129.95.
NETWORK TECHNOLOGIES INCORPORATED
Box 203
Chagrin Falls, Ohio 44022
(216) 543-1646

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IBM MAILING LISTS
Over 100,000 names of IBM personal computer owners (counts increase daily) available for rental on labels or magnetic tape. Total 600,000 including other brands. Plus IBM + compatible retail store + 50 other lists. Call or write for free catalog.
IRV BRECHNER
TARGETED MARKETING, INC.
Box 5125
Ridgewood, NJ 07451
(201) 445-7196

SECURITY

DATA PADLOCK
DATA PADLOCK is a software implementation of the National Bureau of Standard Data Encryption Standard. Written in Assembler. DATA PADLOCK offers max speed with no increase in file size. An 8 character password provides the key for encryption. Protect sensitive data, text or program files from unauthorized access. Works with all DOS versions \$150. VISA/MC.
GLENCO ENGINEERING
3920 Ridge Ave.
Arlington Hts., IL 60004
(312) 392-2492

SOFTWARE/BUSINESS

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MENU-DRIVEN BILLING & ACCOUNTS RECEIVABLE MANAGEMENT SYSTEM. Produces Invoices, Aged Statements, Invoice Journals, Receipts Journals, Aged Customer Account Status, Past Due Notices, etc. Available with modifiable source code for dBASE II users \$129 or as a stand-alone Run-time package \$199.
DATAMAR SYSTEMS
819 Gage Dr.
San Diego, CA 92106
(619) 223-6444

PC ACCOUNTING SYSTEM
Professional Accounting for small business or home use. No codes to forget: all lookups are alphabetic. Shows effect of each entry on the screen in English. Supports 20 business units, 1000 account codes, and 10,000 customers or vendors. Reports by business or consolidated in detail/summarized on screen/printer. Color/mono dual/floppy/hard disk. \$69.95 (VISA/MC/CHECK/COD/MO). NYS add 7% tax.
PEGASUS SYSTEMS, INC. Dept. T
30 Harbour Pointe
Buffalo, NY 14202
(716) 852-2969

IBM PC DATA ENTRY SYSTEM
The Mark I system allows fast and accurate data entry within a Job/Batch environment. The system includes: Entry, Verify, Search, Field totals, Password Security, Field Edits, Custom screen/form design, Comprehensive help facility, MenuDriven and much more. Files can be exported to PC DOS format for additional processing by the PC or for file transfer to other mini or mainframe computers. Runs on: PC, XT & AT. \$295.
SUNUS SYSTEMS INC.
4244 Ridge Lea Road, Suite 25
Amherst, NY 14226
(716) 834-2820

TIME TRACK
Is a time recording and billing system that converts time spent by people within an organization into invoiced amounts. The system is menu driven for ease of operation. Online help screens supplement an extensive user guide. The license price of TIME TRACK is \$495.00.

DOMUS Software Limited
251 Cooper Street
Ottawa, Canada K2P 0G2
1 (613) 230-6285

RATES AND INFORMATION

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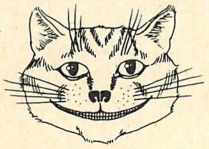

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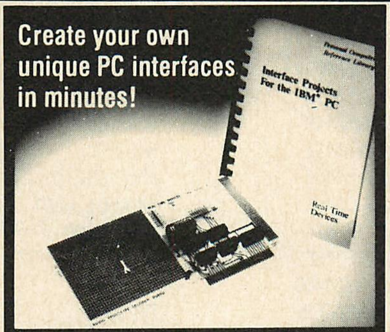

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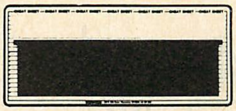

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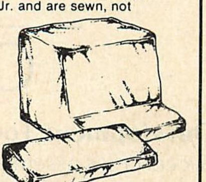

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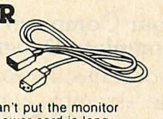

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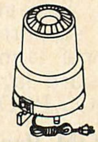

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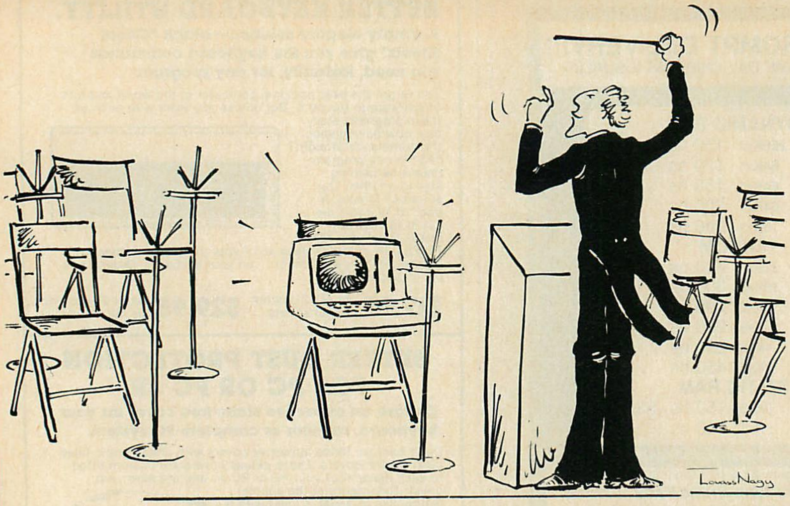

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Sponsor: IEEE
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December 4-6
1984 Real-Time Systems Symposium
Austin, TX
Sponsor: IEEE
Contact: Miroslaw Malek, Computer Science Dept., University of Texas at Austin, Austin, TX 78712, 512/471-5704

December 4-8
International Conference on Robotics and Factories of the Future
Charlotte, NC
Contact: Surendra Dwivedi, College of Engineering, The University of North Carolina at Charlotte, Charlotte, NC 28223, 704/597-4190

December 5-7
Conference on Artificial Intelligence Applications
Denver, CO
Contact: R. Haralick, Dept. of Electrical Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, 703/961-6819

December 10-12
IEEE-CS Computer Networking Symposium
Gaithersburg, MD
Sponsor: IEEE-CS
Contact: David C. Hartmann, Mitre Corp., 1820 Dolley Madison Blvd., McLean, VA 22102, 703/883-6782

December 10-12
IEE Conference on Computer-Aided Engineering
Coventry, England
Contact: Manager, Conference Services, IEE, Savoy Place, London WC2R 0BL, UK, 01-240 1871

December 12-14
International Computer Symposium (ICS 84)
Taipei, Taiwan, Republic of China
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December 13-16
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IEEE First International Conference on Office Automation
New Orleans, LA
Sponsor: IEEE
Contact: Robert W. Taylor, Program Chairman, IEEE ICOA 84, IBM San Jose Research Lab, K52-282, 5600 Cottle Road, San Jose, CA 95193, 408/256-7268

December 19-21
10th Anniversary Symposium—PERFORMANCE '84
Paris, France
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JANUARY

January 13-16
12th Annual ACM SIGACT-SIGPLAN Symposium on Principles of Programming Languages
New Orleans, LA
Sponsor: ACM
Contact: Brian K. Reid, Computer Systems Laboratory, ERL 444, Department of Electrical Engineering, Stanford University, Stanford, CA 94305

January 22-25
UniForum
Dallas, TX
Sponsor: /usr/group
Contact: Richard Lewis, 800/323-5155

January 28-30
Office Automation Conference
Tucson, AR
Sponsor: IEEE
Contact: AFIPS, 1899 Preston White Drive, Reston, VA 22091, 703/620-8900

January 28-30
ACM SIGOPS Workshop on Operating Systems in Computer Networks
Ruschlikon, Switzerland
Sponsor: ACM SIGOPS and IBM Zurich Research Laboratory
Contact: Liba Svobodova, IBM Zurich Research Laboratory, CH-8803, Ruschlikon, Switzerland

January 28-31
Communications Networks Conference & Exposition
Washington, D.C.
Contact: Bill Leitch or Nancy Hedges, CW/Conference Management Group, 800/225-4698 or 617/879-0700

FEBRUARY

February 4-6
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Atlanta, GA
Sponsor: AFIPS
Contact: Trudi Riley, 703/620-8952

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Computer Graphics Exhibition and Conference (WCGA)
London, England
Contact:World Computer Graphics Association, Inc., 2033 M Street, N.W., Suite 399, Washington, DC 20036, 202/775-9556

February 25-28
Compcon Spring '85, Technological Leverage: A Competitive Necessity
San Francisco, CA
Sponsor: IEEE-CS
Contact: Glen G. Langdon, Jr., IBM Dept. K54/282, 5600 Cottle Road, San Jose, CA 95193, 408/256-6454

MARCH

March 4-7
Interface (telecommunications)
Atlanta, GA
Contact: Amy Marks, The Interface Group, 617/449-6600

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